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**EXPERIMENTS IN  
EDUCATIONAL PSYCHOLOGY**



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EXPERIMENTS  
IN  
EDUCATIONAL PSYCHOLOGY

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UNIV. OF  
CALIFORNIA

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## PREFACE

THIS book is designed to serve as a guide for laboratory experiments in educational psychology. Only those experiments have been selected which have a more or less direct bearing upon educational problems. It is intended to be a laboratory manual for experimental work done parallel with an introductory course in educational psychology, or in other introductory educational courses in which the psychological aspect is emphasized.

No previous training in experimental work is necessary. The directions are so given that in most experiments relatively simple apparatus is used. For many experiments the material is contained in the book, for others it may easily be constructed, and for the rest it must be obtained from the sources indicated in each case.

In pursuing the laboratory work the order of the chapters permits of considerable flexibility. All chapters except V and VI are independent of one another and any desired order may be adopted. The work is intended to occupy two hours weekly through one semester. It is best to divide the class into groups of not more than eight or ten, in charge of an instructor who shall see that the experiments are done accurately and the notes written up carefully.

In order to emphasize the practical aspects of the principles brought out in the various experiments, a brief set of exercises is placed at the end of each chapter which should be worked out and handed in as a part of the laboratory notes. Additional references are given to excellent practical problems which may best be assigned for discussion during the recitation hour.

I wish to express my obligations to Professor V. A. C. Henmon, who suggested numerous changes in the manuscript, to Dr. B. Q. Morgan, who read the manuscript, and to Professor W. F. Dearborn, with whose coöperation several experiments, particularly those in Chapters V, VII, and VIII, were planned

D. S.

UNIVERSITY OF WISCONSIN,  
*June, 1911.*

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# EXPERIMENTS IN EDUCATIONAL PSYCHOLOGY

## CHAPTER I

### INDIVIDUAL DIFFERENCES

**Problem.** The experiments in this chapter are introduced with a threefold purpose: first, to show the nature and amounts of differences in mental abilities between individuals; second, to determine to what extent mental ability in one direction is accompanied by ability in other directions; and third, to demonstrate some simple and accurate means of measuring mental functions. In order to gain scientific insight into these problems, four types of mental functions or abilities will be selected for measurement, namely: memory, perception, controlled association, and arithmetical ability.

**Procedure.** 1. **Memory.** a. *Auditory Memory Span.* The purpose of this test is to determine the largest number of unrelated words that can be recalled immediately after one hearing. This test should be conducted by the instructor in charge and performed simultaneously by the en-

tire class, as follows: Be prepared with pencil and paper. The person conducting the experiment will read the following groups of words at the rate of one word per second. Immediately after each group is read, write in correct order all the words remembered. Then the next group will be read, and so on. Do not read the test words given below until the experiment is finished.

Tree, box, chair, ice.

Floor, book, house, pipe, lake.

Fence, card, pin, lamp, coal, horse.

Wood, dog, stone, nest, ink, nail, leaf.

Wall, fork, glass, board, hat, cup, lead, cat.

Bench, snow, watch, man, rose, heart, gold, king, nose.

Girl, plant, bread, skate, roof, corn, boy, door, face, key.

Compare your results with the lists as read and find the largest number of words remembered in correct order from any one group. This is your memory span in the auditory field. The use to be made of this measurement will be pointed out below.

b. *Memorizing.* Learn the following stanza by reading it through entirely, not by parts, and record the exact time in minutes and seconds. Consider it memorized as soon as you can repeat it without consulting the text.

A wanderer is man from his birth.

He was born in a ship

On the breast of the river of Time;

Brimming with wonder and joy,

He spreads out his arms to the light,

Rivets his gaze on the banks of the stream.

## 2. Perception of letters and words.

a. *The E Test.* Cross out with a short horizontal stroke all the *E*'s in the table below. Work as quickly as you can without omitting any. Record the time.

F L B S M R E T H G A U D R E T T E  
 B E N U T R O F A E R B S E S O T D E  
 M I A L C X E R E B T A F E E L B A F  
 E R I G E E E H R E L W O B E C I T O  
 N N E V E D E S H D E W O L L E Y E T  
 H E E N Y L E R I T N E R E V E T A H  
 W T O P E E F O C E S R U O C R E T T  
 E E L A T E M T E S T A E E L P O E P  
 N E T F O S E H I S F D E K O Y R E V  
 N E E B B D A E D Y E T T E R P D E T  
 F L S E M D E R A O R E H T A F E M O  
 C E B N E H W Z E V G E Z Q X K E D

b. *The e-r Test.* Strike out with a horizontal line each word that contains both *e* and *r* in the following text. Record the time.



Sed quoniam, patres conscripti, gloriae munus optimis et fortissimis civibus monumenti honore persolvitur, consolemur eorum proximos, quibus optima est haec quidem consolatio: parentibus, quod tanta rei publicae praesidia genuerunt; liberis, quod habebunt domestica exempla virtutis; coniugibus, quod iis viris carebunt quos laudare quam lugere praestabit; fratribus, quod in se ut corporum, sic virtutis similitudinem esse confident. Atque utinam his omnibus abstergere fletum sententiis nostris consultisque possemus, vel aliqua talis iis adhiberi publice posset oratio qua deponerent maerorem atque luctum gauderent—que potius, cum multa et varia impenderent hominibus genera mortis, id genus quod esset pulcherrimum suis obtigisse, eosque nec inhumatos esse nec desertos, quod tamen ipsum pro patria non miserandum putatur, nec dispersis bustis humili sepultura creatos, sed contactos publicis operibus atque muneribus eaque exstruktionem quae sit ad memoriam aeternitatis ara virtutis.

Quam ob rem maximum quidem solacium erit propinquorum eodem monumento declarari et virtutem suorum et populi Romani pietatem et senatus fidem et crudelissimi memoriam belli, in quo nisi tanta militum virtus exstisset, parricidio M. Antoni nomen populi Romani occidisset. Atque etiam censeo, patres conscripti, quae praemia militibus promisimus nos re publica recuperata tributuros, ea viris victoribusque cumulate, cum tempus venerit, persolvenda; qui autem ex iis quibus illa promissa sunt pro patria occiderunt, eorum parentibus, liberis, coniugibus, fratribus eadem tribuenda censeo.

3. **Controlled Association.** a. *Opposites Test.* Write as quickly as possible the opposite to each word in the following list. Record the time.

Strong	Dark
Deep	Rough
Lazy	Pretty
Seldom	High
Thin	Foolish
Soft	Present
Many	Glad
Valuable	Strange
Late	Wrong
Rude	Quickly

b. *Genus-Species Test.* Write the name of some particular object for each of the class names in the following list, as for example, tree-oak. Work as quickly as possible and record the time.

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Book	State
City	Poet
Writer	Building
Scientist	U. S. president
River	Fruit
Wood	Battle
Flower	Musician
Animal	Lake
King	Street
Grain	Nation

4. **Arithmetical Ability.** a. *Addition.* Add as rapidly as you can the following sets of numbers. Record the time.

364	692	756	637	743
479	423	945	482	274
334	498	247	926	762
<u>652</u>	<u>973</u>	<u>958</u>	<u>496</u>	<u>968</u>

b. *Subtraction.* Perform the subtractions indicated in the following numbers. Record the time.

984	724	982	768	835
<u>845</u>	<u>328</u>	<u>476</u>	<u>372</u>	<u>657</u>

862	987	597	984	942
<u>465</u>	<u>348</u>	<u>435</u>	<u>756</u>	<u>453</u>

**Results.** In order to show the bearing of these experiments upon the question of individual differences, it is necessary to obtain the data of the tests from each member of the class and to compare them with one another. Construct a table to show the name and records of each individual. See Table I.

Draw a curve of distribution for the results of each test showing how many individuals belong to each grade of ability. For example, in the memory span test, let the abscissæ represent the different numbers of words recalled and the ordinates the number of persons possessing these different spans. See the curves in Figs. 1 and 2. In the other tests, the intervals of time should be graded by thirty, fifteen, or ten-second steps. Thus, for the *E*-test, find how many persons finished in from 20-29 seconds, 30-39 seconds, etc.<sup>1</sup>

<sup>1</sup> To economize time, the person in charge should construct the table on the board in coöperation with the class, each person in turn reading off his records. If the class is small, the records in Table I should be used in addition to the ones obtained.

TABLE I

	Memory Span	Memorizing	E Test	E-r Test	Opposites	Genus Species	Addition	Subtraction
1	9	3' 45"	50"	2' 20"	1' 10"	2'	1' 5"	50"
2	6	3'	50"	2'	2' 20"	1' 10"	45"	35"
3	6	2'	45"	3' 30"	1' 45"	1'	1' 10"	45"
4	7	1' 50"	45"	1' 40"	1' 5"	1'	1' 5"	45"
5	6	1' 30"	1' 30"	2' 15"	1' 15"	1' 15"	1' 15"	45"
6	5	2'	1' 30"	3'	3'	1' 30"	2'	2'
7	7	1'	45"	2' 30"	1' 30"	2'	2' 30"	3'
8	5	2' 55"	1'	2' 4"	1' 30"	1'	1'	40"
9	5	4'	30"	1' 40"	1' 30"	1'	1'	40"
10	7	1' 30"	35"	3'	1' 30"	2'	1' 15"	40"
11	6	1' 30"	30"	40"	1'	30"	1'	1'
12	5	3'	58"	1' 35"	1' 15"	1' 10"	1' 15"	45"
13	5	2'	45"	1' 30"	1' 15"	1' 10"	1' 15"	45"
14	7	2'	1'	3'	1'	1' 35"	1'	1' 30"
15	5	2'	1' 15"	2' 45"	1' 10"	1' 30"	1' 20"	45"
16	5	2'	1'	3'	1'	1' 30"	1'	1' 30"
17	5	3' 30"	50"	2'	1' 15"	1' 15"	1' 10"	40"
18	5	1' 30"	30"	1' 30"	1' 20"	1' 15"	30"	35"
19	7	1' 20"	30"	1' 20"	1' 27"	1'	1'	37"
20	6	4' 15"	45"	2' 35"	1'	1' 10"	40"	45"
21	5	3'	45"	1' 30"	1' 10"	1'	1'	45"
22	6	4' 12"	45"	2'	1'	1' 20"	40"	19"
23	6	2'	30"	1'	1'	55"	35"	.....
24	6	2'	50"	1' 35"	1' 30"	1'	1' 20"	50"
25	6	3'	45"	1' 30"	1' 10"	1'	35"	45"
26	7	2'	30"	2'	45"	1' 45"	50"	40"
27	7	2'	50"	2'	1'	1'	30"	45"
28	6	4'	1' 30"	1' 20"	1' 20"	1' 10"	1'	50"
29	6	1' 30"	50"	4'	3' 10"	1'	40"	30"
30	7	2' 20"	50"	4' 10"	1' 30"	1' 25"	2' 30"	1' 50"
31	7	1' 30"	45"	3'	1' 50"	1' 10"	1'	30"
32	6	1' 30"	50"	2' 20"	1' 50"	1' 10"	1' 10"	1'
33	5	2'	45"	1' 30"	1' 35"	1' 25"	1' 22"	1'

TABLE I (CONTINUED)

	Memory Span	Memorizing	E Test	E-r Test	Opposites	Genus Species	Addition	Subtraction
34	7	1' 10"	20"	1' 40"	1'	52"	24"	20"
35	5	3' 15"	45"	2' 30"	1' 8"	48"	39"	27"
36	7	1' 45"	48"	3' 21"	55"	31"	1' 52"	2' 26"
37	6	3'	1'	2' 38"	1' 25"	1' 20"	1' 20"	38"
38	5	2' 30"	35"	2'	1' 5"	1' 15"	1'	1'
39	5	1' 28"	43"	4' 52"	4' 20"	1' 36"	1' 16"	45"
40	6	1' 30"	40"	2' 15"	1' 15"	1' 20"	30"	25"
41	6	3'	30"	3' 10"	2' 15"	1' 30"	1'	30"
42	7	1' 35"	54"	4' 4"	1' 20"	1' 16"	1' 4"	48"
43	7	4'	1' 15"	3' 30"	4'	1' 30"	46"	45"
44	6	3'	30"	1' 53"	1' 20"	1' 18"	1' 10"	55"
45	5	1' 40"	58"	1' 20"	1' 22"	1' 15"	1' 15"	1' 2"
46	5	4'	1'	2'	1' 50"	1' 30"	1' 30"	58"
47	5	2'	30"	4' 30"	1' 20"	1' 25"	1' 18"	46"
48	6	1' 10"	55"	1' 10"	1' 40"	1' 55"	1' 20"	48"

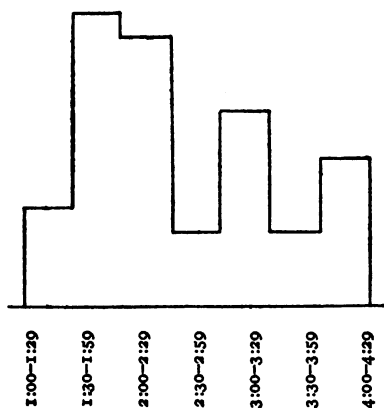


FIG. 1.—Memorizing.

Discuss the following questions:

1. To which grade of ability do the majority of indi-

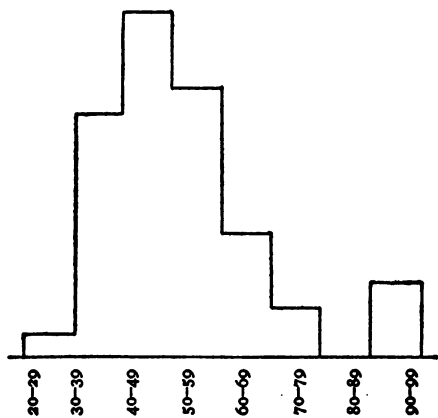


FIG. 2.—E Test.

viduals in these tests belong, superior, medium, or inferior?

2. If you divide the entire range of abilities into three equal parts, what proportion of individuals belong to each part? For example, what percentage of persons have a memory span of from four to five, six to seven, eight to nine? In this manner make a composite table of all the tests to show the percentage of persons in each third.

3. On the basis of these distribution curves, would it be fair to divide a group of persons into, for example, two distinct groups, bright and dull? Why?

4. How much better are the superior individuals than the inferior ones? For example, in the *E* test in Table I,

the best record is 20 seconds, while the lowest is 1 minute, 30 seconds. That is, the best one is four and one-half times as fast as the slowest one. Construct a table to show this comparison for all the tests.

5. What application has the curve of distribution to the assignment of grades in school studies?

The following are the grades of a class in psychology:

86, 80, 86, 83, 78, 80, 88, 85, 82, 83, 86, 88, 84, 84, 88, 83, 86, 88, 86, 83, 90, 86, 86, 86, 84, 80, 86, 80, 82, 78, 82, 88, 86, 80, 86, 84, 93, 86, 68, 85, 84, 86, 84, 90, 88, 88, 86, 80, 86, 93, 82, 88, 86, 90, 82, 78, 97, 75, 73, 78, 86, 86, 82, 86, 88, 78, 80, 86, 82, 90, 70, 80, 90, 84, 82, 76, 86, 78, 84, 84, 88, 83, 70, 86, 84, 82, 90, 82, 88, 78, 88, 90, 86, 86, 93, 78, 86, 86, 90, 75, 86, 84, 76, 84, 76, 84, 75, 84, 86, 70, 90, 95, 90, 84, 80, 93, 70, 82, 80, 84, 83, 86, 83, 86, 86, 86, 84, 84, 82, 86, 83.

Construct a distribution curve. Should this curve be similar in form to the curves obtained from the experiments? Why? What criticism of these grades can you suggest?

6. One of the most significant facts of individual differences is that persons ranking high in one ability are as a rule not equally superior in other abilities. A bright pupil in history may not be much above the average in arithmetic, and *vice versa*.

In order to demonstrate in a rough way to what extent such relations or lack of relations between mental functions exist, draw a circle around each of the five best records made in each of the eight tests. How many



persons, if any, come within the first five in all the tests? If a person's abilities are equally superior, or nearly so, in all the functions tested, all his records should be found among the first five.

Indicate the five poorest records in each test by squares. Are the persons who make the poorest records in memorizing the same as those who make the poorest in the other tests? How many are the same? Similarly, compare the memory span with the memorizing test, and likewise the other pairs of tests.<sup>1</sup>

For further practical exercises and applications to school work see Thorndike, *Principles of Teaching*, pp. 98-104.

<sup>1</sup> The accurate way of representing relations between mental capacities is by means of the coefficient of correlation. See Thorndike, *Educational Psychology*, First Edition, p. 26.

## CHAPTER II

### VISUAL TESTS AND DEFECTS

THE eye is the most important avenue of information. The need of care in preventing abuse and in correcting defects is patent to everyone. Every teacher should know something of the common types of visual defects, and how to detect them.

1. **Far- and Near-Sightedness.** In order to see an object distinctly the rays of light from that object must come to a sharp focus upon the retina. If not, the object appears blurred.

a. *The Function of Accommodation.* Accommodation is the change in the shape of the crystalline lens in order to focus the image upon the retina. For a distant point the lens flattens and for a near point it bulges.

Set the end of a ruler against the cheek below the right eye so that it points in the direction of sight. Close the left eye. Hold a pin (point upward) at a distance of about thirty centimetres so that the point can be seen distinctly. Then gradually slide it along the edge of the ruler toward the eye until it comes to the place where the point begins to blur. Slide it outward until the point again appears distinct. This is the near point of vision.

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Measure and record the distance from the eye. Make five measurements for the right and five for the left eye. For the normal eye, at the age of twenty, this distance is about twelve to fifteen centimetres. For the near-sighted eye it is less, and for the far-sighted eye it is more.

Hold the pin at the distance just determined and set a page of print about twenty centimetres beyond the pin. Notice that as you focus on the pin the print appears blurred. As you focus on the print the pin appears blurred. Notice also the feeling of effort or strain in the eye as you shift from the print to the pin.

In myopia, or near-sightedness, the eyeball usually is too long. The image is formed at a point in front of the retina. In hyperopia, or far-sightedness, the eyeball is ordinarily too short and the image would be formed at a point back of the retina. In the latter case it requires constant strain of the ciliary muscles to see near objects distinctly.

Defects of accommodation are accentuated in large part by the effort and strain in the ciliary muscles which control the lenses when looking at objects near by, as, for example, in reading. They may also be due to loss of elasticity in the lens or lack of responsiveness in the ciliary muscles. When the eyes are at rest they are focussed for distant points. Demonstrate this by closing your eyes for a few seconds, and then opening them. Notice that they are adjusted for distant objects and that it requires special effort to focus them upon the page in front of you.

b. *Snellen's Test*.<sup>1</sup> Hang the chart on the wall in good light, but not in direct sunlight. Be seated directly in front of it at a distance of twenty feet. Test each eye separately. Hold a card in front of one eye while the other eye is being examined. Do not press against the eyeball. Begin at the top of the chart and read aloud down as far as you can. The experimenter stands near the chart and takes note of the errors. Record the results of each eye separately in terms of a fraction in which the numerator is twenty and the denominator is the number at the right of the last line read correctly. Thus, if the fraction is  $\frac{20}{30}$ , it means that the last line read correctly is the one marked twenty feet, the distance at which the normal eye should be able to read it. If the fraction is  $\frac{20}{10}$ , or less, the eye is probably near-sighted. If the 10 or 15 feet lines can be read the eye is probably far-sighted. In either case, it should receive the attention of a physician.

It is well to use several different vision charts so that the letters may not be memorized. If only one chart is at hand the results should be verified by covering with two cards all the letters in a given line, except the one to be read. Expose the letters in irregular order.

2. *Astigmatism*. Use the chart which has the radiating lines. These are numbered like the figures on a clock. Hang the chart in good light and sit at a distance of twenty

<sup>1</sup> Snellen's Vision Charts, Cogan's Prism Chart, and Holmgren's worsteds can be obtained from F. A. Hardy & Co., 131 Wabash Ave., Chicago.

feet. Cover one eye with a card, while the other eye is being tested. Look at the chart and notice whether any of the radii appear darker. Record these by their numbers. To the normal eye the radii should appear equally distinct. If they appear considerably different the eye is astigmatic.

3. **Strabismus, or Heterophoria.** This includes all those defects which are due to the lack of proper coördination of the two eyeballs so that the two eyes do not converge simultaneously upon the same point. This condition is due to the fact that the external muscles of the eyes are not properly counterbalanced. The extreme form is commonly called cross-eyes. There are, however, many slight degrees of strabismus which can scarcely be noticed and yet have a very detrimental effect upon vision. The unbalanced eye receives a distorted image and the burden of sight falls upon the other eye. Demonstrate this by looking at some object, say a book, and pressing your finger against the lower side of one eyeball. Notice the distortion of vision.

To detect the presence of strabismus, make the following test: Hang the Cogan Prism chart about six inches away from the wall. Place a lighted candle or lamp just back of the small opening at the centre of the chart. Take a position twenty feet from the chart so that the eyes are on a level with the aperture. The light must be seen directly through the opening.

Close one eye and hold the red glass close before the other eye, so that the red image can be seen. Then look

with both eyes at the flame and notice the location of the red image. Does it coincide with the yellow flame? If not, record its position in terms of the circles and radii of the chart. Shift the glass to the other eye and again record the position of the red image. If the eyes are in perfect balance the two images should coincide. If not, the degree and nature of the deviation will be indicated by the distance and direction of the red image from the yellow flame.

**4. Color-blindness.** Take the three standard colors, labelled A, B, and C, of Holmgren's worsteds and place them on the table a foot or more apart. Select from the other worsteds all those which are like or similar to each of the three standards. Arrange the colors in each group in the order of their brightness. Do this as quickly as you can. Record the time required and the order of the worsteds by writing down their numbers in the order in which you arranged them.

Defective color vision will be indicated by the long time required to arrange the worsteds and by the confusion of the colors. The grouping of the worsteds is correct if they are arranged in the order in which they are numbered. Red-green blindness, the most common form, will be revealed by the confusion of the red and the green yarns.

Discuss the following questions:

1. What use may a teacher make of the knowledge of the visual defects of individual pupils?
2. How may she assist such pupils?

3. How would color-blindness be a drawback in school work?

For further practical exercises see Thorndike, Principles of Teaching, 17-20. O'Shea, Dynamic Factors in Education, Ch. 17.

## CHAPTER III

### AUDITORY TESTS AND DEFECTS

THE school is concerned with two auditory problems, acuity of hearing and discrimination of pitch. The former is of interest to every teacher, the latter is of importance primarily to the teacher of music.

1. **Acuity of Hearing.** The problem is to determine whether an individual's hearing is normal or whether there is any degree of deafness present in either or both ears. Several forms of tests will be used.

a. *The Watch Test.* Perform the experiment in a quiet room. The subject is seated on a chair. Fasten the zero end of a tape measure to the back of the chair just behind the ear to be tested. The other ear should be closed with cotton. Hold the watch so that it can be heard readily. Then gradually move it outward along the aural axis (the line passing through the two ears) until it can no longer be heard. Hold the tape with the other hand and measure the distance of the watch from the ear. Then begin from a position where it can not be heard and move it toward the ear. As soon as it can be heard, stop and measure the distance. Always hold the watch in the same



way with the same side toward the ear. Move it at the rate of about one inch per second. Make five "in" and five "out" measurements for each ear in the double fatigue order, that is, three on the first ear, five on the second, and two more on the first. Average the results for each ear separately.

The advantages of this test are that it is simple, convenient, and sufficiently accurate for crude measurements. Its disadvantages are that watches differ and that the sound is rhythmic, which is apt to deceive the listener into hearing the ticking when he actually does not. In order to make the records of different persons comparable, the same watch should be used.<sup>1</sup>

b. *Seashore's Audiometer*. This is an accurate, convenient instrument, and on the whole the best for measuring acuity of hearing.<sup>2</sup>

Adjust the strength of the electric current by means of the resistance plugs and the galvanometer until the needle of the latter rests on the central cross bar. Connect the receiver with the audiometer and mount it on a tripod in another room. The subject is seated so that the ear

<sup>1</sup>The Politzer acoumeter may be used in exactly the same manner as the watch. The sound in this instrument is produced by a small metallic hammer. It is superior to the watch in that the stimuli are uniform and can be produced at will.

<sup>2</sup>A description of this apparatus may be found in the Univ. of Iowa Studies in Psych., 1898, II., 158-163. It consists essentially of a series of induction coils by which the stimulus can be varied from very weak to moderately strong intensities. The instrument can be obtained from C. H. Stoelting Co., 121 N. Green St., Chicago.

can be held as close as possible to the receiver without touching it. A key and telegraph sounder should be set up, the former being placed in the hands of the subject and the latter in the room with the audiometer. The subject responds on this key whenever he hears the stimulus from the receiver.

The sliding key on the audiometer is for the purpose of changing the intensity of the stimulus. To make the measurements, begin with a sound which can easily be heard. Diminish the intensity of the stimulus step by step until the subject no longer responds. Give the stimuli at irregular intervals of from three to six seconds, so that the subject may not tend to respond rhythmically. Record the last sound heard. Begin several units below this point and increase the intensity of the stimuli until the subject again responds. Record the first one heard. In this manner make five measurements on each ear in the double fatigue order. Average the results. Compare them with the watch test. Is the acuity of the two ears the same?

c. *The Whisper Test.* This test may be omitted, but it is introduced here because it is often a serviceable method in the school-room. The pupil is stationed at a distance of fifteen or twenty feet from the examiner with one ear toward him. Then a series of twenty-five words, preferably numbers, are spoken in a whispered voice. After each word the child writes down what he heard. Ten or twelve pupils may easily be tested at one time. Then the pupil turns so that the other ear is toward the exam-

iner and the test is repeated. After the test, the pupil's list is compared with the examiner's list, and the percentage of errors determined. It requires some practice on the part of the examiner to whisper the words fairly uniformly. The results are entirely relative, and different pupils must be compared with one another. The pupil who has considerably more than the average percentage of errors should receive medical attention. The one great advantage of the whisper experiment is that it tests hearing of conversational speech, which is not the case when mechanical stimuli are used.

**2. Discrimination of Pitch.** One of the essentials for musical training is the capacity to make fine discriminations of pitch. A convenient and accurate method of testing musical discrimination is afforded by a series of eleven graded tuning-forks<sup>1</sup> which range in pitch from 435 vibrations (the standard) to 465 vibrations. The forks between these limits are graded in the following order, each being so many vibrations higher than the standard:  $\frac{1}{2}$ , 1, 2, 3, 5, 8, 11, 17, 23, 30.

Mount a speaking-tube so that the subject may hold one end of it to his ear. The experimenter holds the

<sup>1</sup> This series can be prepared from a set of A forks whose prongs are approximately three and a half inches long. They can be obtained through any music dealer. One of the forks is selected as standard and the others are tuned according to the required interval above the standard by filing the ends of the prongs until they have the desired pitch. They can be tuned accurately by comparing each fork with the standard and with one another and counting the beats. This method of testing was first devised by Seashore. See Univ. of Iowa Studies in Psych., II., 55-64.

vibrating forks at the other end of the tube. If no speaking tube is at hand, the forks may be held close to the ear. Or, better, roll a sheet of paper to make a tube an inch in diameter and hold that to the ear. The stimuli can thus be given more uniformly than by holding the forks to the ear.

The experimenter strikes the standard and the highest fork and holds them in rapid succession before the tube. They should be struck as uniformly as possible and held to the tube not longer than two or three seconds, with as short an interval between the two forks to be compared as possible. The subject indicates whether the second is higher or lower than the first. If the answer is correct the standard and the twenty-three fork are compared in the same manner. If that judgment is correct, the standard and the seventeen fork are taken, and so on until the subject makes a mistake. Then, with these two forks, make twenty trials and record each judgment as right or wrong. If less than seventy per cent. of the answers are correct, make twenty trials with the standard and the fork next above the one just used. If more than eighty per cent. are correct, make twenty trials with the standard and the fork next below the one used. The two forks with which approximately seventy-five per cent. of the answers are correct may then be regarded as the measure of the threshold of pitch discrimination. An average is difficult to give because individuals differ greatly in this respect. For university students the average is between five and eight vibrations.

## 24 EXPERIMENTS IN EDUCATIONAL PSYCHOLOGY

Discuss the following questions:

1. In what ways may the teacher assist a deaf pupil?  
A pupil deaf in one ear only?
2. What changes would you suggest to be made in the musical instruction of a pupil who has poor discrimination of pitch? <sup>1</sup>

<sup>1</sup> Cf. Seashore, Educational Review, Vol. 22, p. 75.

## CHAPTER IV

### MENTAL IMAGES

THE problem is to determine the relative predominance of the different types of mental images.<sup>1</sup>

**1. The Frequency of Different Classes of Mental Images.** Determine this by the association method in the following manner. The material to be used consists of the columns of words printed below. Cover with a piece of paper all the words except the first column. With another piece of paper cover this column also. Slide it down far enough to expose the first word. Then in a short sentence write in your notebook an answer to this question, "What do you think of as soon as you see that word?" For example, if the word is "grass," it might suggest at once imagery of this kind, "I think at once of the green appearance of a meadow." Or, if the word is "shoe," it might suggest such an answer as this, "I think of the pinching of my new shoe." Do not try to make a selection, but write down whatever comes to your mind first. Write your answer quickly and proceed to

<sup>1</sup> The student should be familiar with the meaning and nature of mental images. Some standard text on psychology may be consulted, e. g. James, *Psychology*, Chap. 19; or Angell, *Psychology*, Chap. 8.

the next word by sliding the paper down to expose it. Answer the same question with regard to this word. Similarly, work through the entire list of words. Number your answers. Keep all the columns covered except the one you are using. The purpose of this is to avoid as far as possible the associations with other words except the one before you.

I	II	III	IV
Nouns	Verbs	Nouns	Verbs
1. bell	1. whistle	1. iron	1. couch
2. piano	2. sing	2. stove	2. walk
3. railroad	3. knock	3. knife	3. burn
4. music	4. cry	4. cap	4. run
5. storm	5. laugh	5. needle	5. sting
6. clock	6. hiss	6. snow	6. write
7. hammer	7. rattle	7. soap	7. bite
8. drum	8. bark	8. brush	8. pull
9. wagon	9. march	9. wool	9. lift
10. dog	10. whisper	10. apple	10. fall

Put the results in the form of a table showing how many of the forty words aroused visual images, auditory, motor, tactile, etc. In the illustrations given above, "grass" brought out visual images, "shoe" at once suggested tactile images, etc. Calculate the percentage of each class.<sup>1</sup>

<sup>1</sup> Pfeiffer, L., Ueber Vorstellungstypen, Pädagogische Monographien, 1907, Leipzig.

TABLE II

FREQUENCY OF THE DIFFERENT CLASSES OF IMAGES OF  
TWENTY-SIX PERSONS

	Visual	Auditory	Motor	Tactile	Miscellaneous
1.....	25	9	6	..	..
2.....	37	2	1	..	..
3.....	18	10	7	5	..
4.....	26	8	4	1	..
5.....	25	9	3	1	2
6.....	15	12	4	9	..
7.....	16	13	6	5	..
8.....	19	14	5	2	..
9.....	19	9	7	1	4
10.....	24	7	6	..	..
11.....	15	13	2	10	..
12.....	36	4	..	..	..
13.....	15	10	5	10	..
14.....	20	10	8	2	..
15.....	28	9	2	1	..
16.....	31	6	1	1	1
17.....	16	8	7	3	6
18.....	15	8	8	8	1
19.....	16	10	10	4	..
20.....	19	5	10	5	..
21.....	15	10	8	6	1
22.....	23	11	1	5	..
23.....	12	11	11	6	..
24.....	16	10	10	4	..
25.....	12	12	9	5	2
26.....	17	11	8	3	1
Averages..	20.4	9.3	5.8	3.8	.7
Percentages	51.	23.3	14.5	9.5	1.7

2. **The Vividness of Mental Images.** This is to be determined by an introspective questionnaire. Use the following list of questions.<sup>1</sup>

<sup>1</sup>From Seashore, *Elementary Experiments in Psychology*, 106-111, by permission of Henry Holt & Co. and the author.



" This is a distinct exercise in introspection. It is best to keep the eyes closed as you introspect. If the observer does not have strong imagery he may be lost in the effort to create an image out of the retinal light. To avoid this, it is best to think of the object as in a distant place; for example, the rose on the bush.

" Sometimes the image comes in the most realistic way when it comes without effort as a sort of a reverie image which passes the mental horizon. As a rule, it is best not to direct the attention primarily to the detail of the image, but rather to the effort to recall the fact; when the fact comes into consciousness the character of the image may be observed.

" Fix clearly in mind and use as consistently as possible the following scale of degrees of vividness:

- o. No image at all.
1. Very faint.
2. Faint.
3. Fairly vivid.
4. Vivid.
5. Very vivid.
6. As vivid as in perception.

" Answer the following questions by writing after the number of the question the number which denotes the degree of vividness characteristic of your image. Instead of taking the questions in the order given, follow the order: I-1, II-1, III-1, IV-1, V-1, VI-1, VII-1, VIII-1, I-2, II-2, III-2, IV-2, etc., I-3, II-3, III-3, IV-3, etc. Introspective

notes to supplement the numerical answers are very desirable.

I. Visual.—1. Can you image the color of—(a) A red rose? (b) A green leaf? (c) A yellow ribbon? (d) A blue sky?

2. Can you image the brightness of—(a) A white teacup? (b) A black crow? (c) A gray stone? (d) The blade of a knife?

3. Can you image the form of—(a) The rose? (b) The leaf? (c) The teacup? (d) The knife?

4. Can you form a visual image of—(a) A moving express train? (b) Your sharpening of a pencil? (c) An up-and-down movement of your tongue?

5. Can you image simultaneously—(a) A group of colors in a bunch of sweet peas? (b) Colors, forms, brightnesses, and movements in a landscape view?

6. Can you compare in a visual image—(a) The color of cream and the color of milk? (b) The tint of one of your finger-nails with that of the palm of your hand?

7. Can you hold fairly constant for ten seconds—(a) The color of the rose? (b) The form of the rose?

II. Auditory.—1. Can you image the sound of—(a) The report of a gun? (b) The clinking of glasses? (c) The ringing of church bells? (d) The hum of bees?

2. Can you image the characteristic tone quality of—(a) A violin? (b) A cello? (c) A flute? (d) A cornet?

3. Can you repeat in auditory imagery the air of—(a) Yankee Doodle? (b) America?

4. Can you form auditory images of the intensity of a

violin tone—(a) very strong; (b) strong; (c) weak; (d) very weak?

5. Can you form auditory imagery of the rhythm of—  
(a) The snare-drum? (b) The bass-drum? (c) 'Dixie,'  
or other air heard played? (d) 'Tell me not in mourn-  
ful numbers' spoken by yourself?

III. Motor.—1. Can you image, in motor terms, your-  
self—(a) Rocking in a chair? (b) Walking down a stair-  
way? (c) Biting a lump of sugar? (d) Clenching your  
fist?

2. Does motor imagery arise in your mind when you  
recall—(a) A waterfall? (b) A facial expression of fear?  
(c) The bleating of sheep? (d) Two boys on a teeter-  
board?

3. Aside from the actual inceptive movements, do you  
get motor imagery when recalling—(a) A very high tone?  
(b) A very low tone? (c) Words like 'Paderewski,'  
'bubble,' 'tete-a-tete,' 'Hurrah!'?

4. Can you form motor images of—(a) An inch? (b)  
A yard? (c) A mile?

5. Can you form a motor image of—(a) The weight of  
a pound of butter? (b) Your speed in running a race?  
(c) The speed of an arrow?

IV. Tactual.—1. Can you form a tactual image of the  
pressure of—(a) Velvet? (b) Smooth glass? (c) Sand-  
paper? (d) Mud?

2. Can you form tactual imagery of the following im-  
pressions made in the palm of your hand—(a) The size  
of a certain coin? (b) The form of the same coin? (c)

The direction of a line traced by a pencil point? (d) The intermittent touch of a vibrating body?

3. Can you form tactual imagery of—(a) The flow of water against the finger? (b) The sensation from a pressure spot? (c) The weight of a particular coin in the hand?

V. Olfactory.—1. Can you image the odor of—(a) Coffee? (b) Camphor? (c) An onion? (d) Apple-blossoms?

2. Can you image odors from—(a) A meadow? (b) A confectioner's shop?

VI. Gustatory.—1. Can you image the taste of—(a) Sugar? (b) Salt? (c) Vinegar? (d) Quinine?

2. Can you image the taste of—(a) An apple? (b) A chocolate cake? (c) Beefsteak?

VII. Thermal.—1. Can you image the coldness of—(a) Ice cream? (b) A draught of cold air? (c) The sensation from the stimulation of a cold spot?

2. Can you image the warmth of—(a) Hot tea? (b) A warm poker? (c) A warm bath? (d) The sensation from the stimulation of a warm spot?

VIII. Pain.—1. Can you secure a sensory image of the pain of—(a) The prick of a pin? (b) Running your finger along the edge of a sharp knife? (c) A toothache or headache? (d) The stimulation of a pain spot?"

Find the average for each of the eight classes of images and plot a curve as in Fig. 3, in which the horizontal line represents the types of images and the vertical line the averages of their vividness.

3. Another method which is useful primarily to dis-

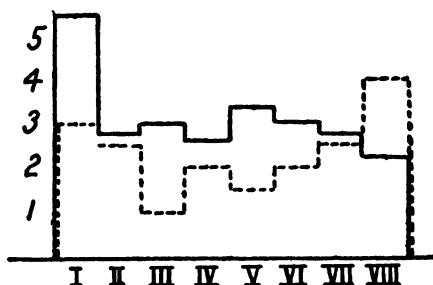


FIG. 3.—Records of Two Persons

tinguish the visualizer from the auditory-motor individual is as follows:

Commit to memory the accompanying pattern of letters by reading from left to right.

k n p  
s o h  
g r w

Lay the book aside and attempt to recall the three vertical columns beginning at the bottom. Then recall the diagonals beginning at the left, then the vertical columns beginning at the top, and finally the horizontal lines beginning at the right. Are you able to do this without having to repeat the letters until you come to the desired one? For example, in recalling the vertical columns from below, do you have to repeat the letters until you come to the first one in the last line? Or can you visualize the entire pattern and read off, as it were, from the mental picture the particular succession of letters called for? The latter person would be predominantly a visualizer,

while the former would be predominantly an auditory-motor person.

Discuss these questions:

1. In which school studies and exercises would strong visual imagery be a distinct advantage? Motor imagery?
2. What advantage might there be for a teacher to know what her dominant class of imagery is? If a person is strongly of one type, illustrations and explanations in teaching are apt to be taken from that field of imagery. How would these affect pupils of a distinctly different type?
3. Would it be advisable to separate pupils into different classes according to their prevailing imagery? See Thorndike, *Principles of Teaching*, 89.
4. Is it advisable to appeal to only one type of imagery in teaching?

## CHAPTER V

### THE TRIAL AND ERROR METHOD OF LEARNING

**Types of Methods.** There are three methods by which the doing of a definite act may be learned.

a. By trial and error, that is, by making random attempts until by chance some attempts are successful.

b. By imitation, that is, by observing the performance of the act and then attempting to copy it.

c. By reasoning, that is, by attempting to think it out and then proceeding accordingly.

The most fundamental of these is the trial and error method. The acquisition of all motor control is accomplished primarily by this method. The others serve only as supplementary aids. For example, in learning to strike a ball with a bat the boy begins by attempting to strike it. He will probably not even succeed in touching it until after several attempts, when the ball and bat happen to meet. As he continues, the successful trials become more and more frequent, while the failures gradually diminish. Learning to strike the ball may possibly be facilitated by observing and imitating an expert batter, but the attempt to reason as to how to strike would probably be of little or no assistance in this particular case.

**The Problem of the Experiment** is to demonstrate the trial and error method of learning, its nature and significance in learning to coördinate perceptual and motor factors. To show this satisfactorily it is necessary to test the process of learning a relatively new and undeveloped act. For this purpose we shall use mirror writing. This consists essentially in the establishment of a new connection between hand movements and the visual perception of these movements as seen in a mirror.

**Material and Apparatus.** Prepare the following material for the experiment: Lay a piece of cardboard back of Fig. 4. Prick through the page with a pin at the apexes of the twelve angles of the star outline. Connect these points with straight lines and then trim the card to produce a six-pointed star pattern. Lay the pattern on a sheet of paper and trace a line around it, making an outline like Fig. 4. Insert the arrow and cross line in their appropriate places. Draw eleven such outlines, each on a separate sheet of paper.<sup>1</sup>

Set a mirror on the table about eighteen inches from you and facing toward you. Set it in a vertical position and at right angles to your median plane. The mirror must be at least six by six inches. It may be held in position by means of books or other convenient objects placed against it. The face of the mirror, however, must be left free.

**Procedure.** Lay one of the star outlines on the table

<sup>1</sup> In order to economize time, it is well to have a rubber stamp made by means of which the patterns may be prepared quickly.



just in front of the mirror so that the arrow is nearest the mirror. Fasten the sheet to the table with two pins. By means of a pencil trace with the left hand just one-half

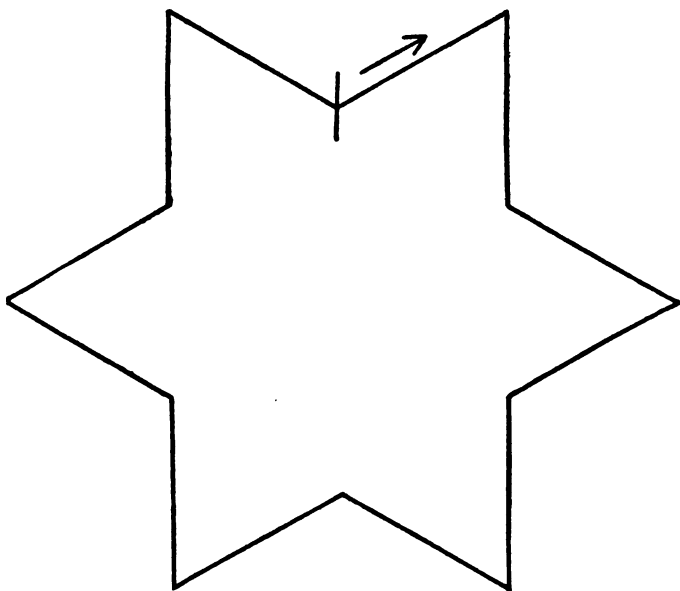


FIG. 4.

of this outline. Begin at the crossbar and go in the direction in which the arrow points. Record on this outline the exact time in seconds which it took to trace this half. Also label it properly as being the first half done with the left hand. Lay this sheet aside. Then trace with the right hand the remaining ten outlines, doing each one completely. Number them in the order in which

you do them. Record on each the time required to do the tracing of that particular outline.

Observe your hand only in the mirror. Never observe it directly. To guard against this a piece of cardboard can easily be clamped to a tripod to intercept the direct view. Follow the line as closely as possible. As soon as you notice that the pencil is beside the line, attempt to get back. In doing this, do not lift the pencil from the paper. The first tracing will usually be difficult. It is therefore important to persist.

**Results.** Construct a table to show (a) the time in seconds required for each tracing, and (b) the number of errors made in each tracing. By an error is meant a correcting movement as shown in Fig. 5. Each attempt to return to the line, whether successful or not, is counted as an error. Plot the results in two curves, placing the

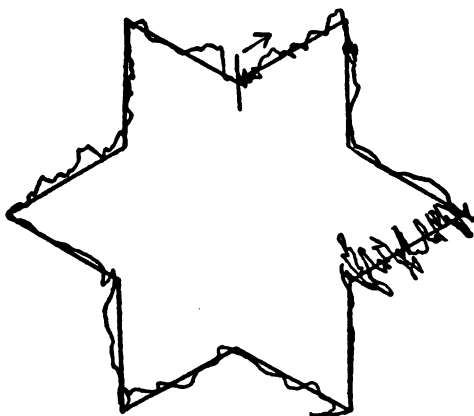


FIG. 5.

number of trials on the horizontal line and the time and errors on the vertical line. See Fig. 6.

Discuss the following points:

1. Examine the two or three places in your first tracing

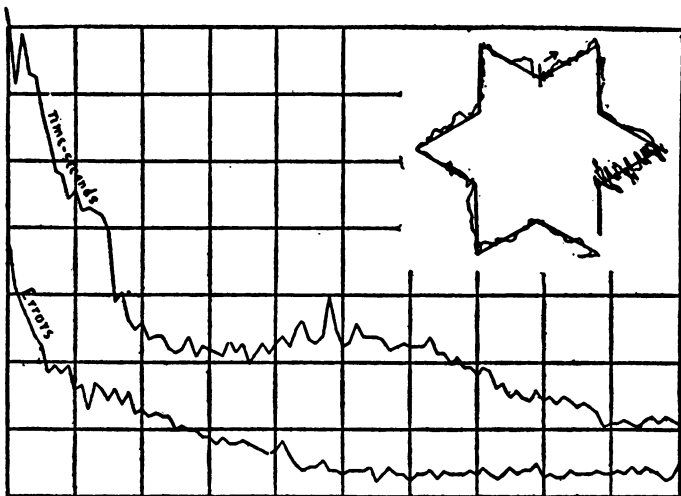


FIG. 6.

which were especially difficult, such as are shown in Fig. 5, where a large number of random movements were made in all directions. Did you find in these difficult places that the determination to move in a certain desired direction resulted in movement in that direction? Or, did you find that you were about as apt to go in some other direction? The experiment shows that you learn to trace the line by the "try, try again" method. Thinking, or making up your mind to move here or there gives little or no assistance.

2. Did you notice any feeling of pleasure or satisfaction when you were successful in returning to the line? If so, in what way would that help in the later records?

3. In what respect is your process of learning in this experiment similar to a child's learning to write?

4. Is the latter more difficult for the child than the former is for you? If so, why?

The importance of the method of trial and error in the development of the motor life of the child is exceedingly great. We can realize its significance only when we remember that all of the activities which involve muscular coördination are acquired by this method. It is in this manner, for example, that the child learns to reach successfully for an object before him. Many random attempts to reach are made until the hand grasps the object. He learns to walk, to control his head, to move the arms and fingers in desired ways largely by trial and error. Of course, for many of these activities there are instinctive tendencies, but these are for the most part indefinite and often consist of little more than a great abundance of impulses to act.

It seems, therefore, important that the teacher should know the nature and meaning of the trial and error method, that she should realize its fundamental importance in the development of child life, that she should understand what school exercises are learned wholly or largely by this method and which can be acquired more quickly by stimulating other modes of learning, and that she should appreciate something of the difficulty in acquiring accu-

rate muscular control such as is involved in, for example, learning to write.

For more complete discussion of the practical and theoretical bearings of this mode of learning the following references may be consulted: Kirkpatrick, *Fundamentals of Child Study*, pp. 81-86. O'Shea, *Dynamic Factors in Education*, pp. 110-121. Bagley, *The Educative Process*, pp. 242-243.

## CHAPTER VI

### THE PROGRESS OF LEARNING

#### 1. Rate of Improvement

**The Problem** is to determine (a) the general rate of improvement, (b) whether improvement progresses at a uniform rate from beginning to end, and if not, when it is most rapid and when least rapid, (c) whether there are periods of improvement and retardation, and (d) the effect of a long interval of rest.

For the investigation of these problems the type of learning begun in the last experiment will be continued. It is well adapted to this purpose for the reason that a considerable amount of improvement can be accomplished in a relatively short period of time and for the reason that considerable practice has already been attained in it.

**Material.** Prepare twenty-five star outlines as directed in the last chapter.

**Procedure.** Continue the mirror tracing exactly as directed before. Try to improve as rapidly as you can, both in the time and accuracy of tracing. In order to avoid the disturbing effect of fatigue it is well to alternate the preparation of the outlines with the tracing. For example, prepare five outlines, then trace five, etc. Num-

ber the tracings in the order in which you do them. Record on each the exact time required to trace it. After all the tracings are done return to the one begun with the left hand and finish the remaining half.

**Results.** Construct a table showing the time and errors of each record. Plot curves from these data, making them continuous with the curves drawn of the ten records made in the preceding chapter. Indicate the points of junction by short cross lines. Calculate the percentage of improvement, comparing the last right-hand tracing with the first. Do the same for the two left-hand outlines.

State your conclusions, and in connection with these discuss the following points:

1. Which part of the curve shows the most rapid improvement? Would you expect to find the same fact in all forms of learning?

2. Is there any indication of periods of more rapid improvement followed by periods of little or no improvement, or possibly even loss? What explanation can you suggest?

If no distinct periods or "plateaus" are recognizable, it is probably due to the fact that the practice has not been continued long enough. These "plateaus" can be seen in Fig. 6, which represents one hundred tracings made at the rate of one a day for one hundred consecutive days.

3. Does the time curve show improvement at the same or at different periods from the error curve? For example, in Fig. 6 the two curves show parallel improvement during

the first rapid period of learning. After that the error curve continues to improve, while the time curve actually shows a loss until the former has reached its "dead level," after which the time curve begins to drop again. This would indicate that a plateau shows lack of improvement only in the particular phase of the learning process represented by that particular curve, and that there is more rapid development in some other phase of the process.

4. Examine the individual records to see whether improvement in time is more frequently accompanied by little or no improvement in errors than by distinct reduction of errors.

5. What is the effect of the long interval between the tenth and eleventh records, that is, the last record of the preceding chapter and the first of this one?

6. Compare the improvement of the left hand with the right hand. How do you explain it? What significance might this have for the spread of practice?

## **2. Factors Affecting the Rate of Learning. Selecting the Successful Trials**

**Problem.** The progress of learning depends largely upon the selection of the successful acts and the corresponding diminution of the random and unsuccessful acts. Whatever factors condition the emphasis and selection of the successful trials promote the rapidity of learning.

The problem of this experiment is to determine the effect of selecting the successful acts. For this purpose



we shall compare a process of practice in which such selection is present, with practice from which it is absent.

**Material.** Several sheets of paper and a pencil.

**Procedure.** Close your eyes and draw with the right hand twenty-five circles approximately two centimetres in diameter. The arm should not rest upon the table, but should be supported entirely from the shoulder. The aim in drawing is to make complete circles. Attempt to stop as nearly as possible at the point from which you started. The distance between these two points will be considered the error. Draw slowly and carefully, taking from five to ten seconds for each circle. Make the circles in rows either across the page or down the page, in order that you may know later the exact order in which they were drawn. It is important to keep the eyes closed during the entire task. After you have drawn the last circle turn over your sheet and lay it aside, before you open your eyes.

On the next sheet draw another series of twenty-five circles. In this series open your eyes between the consecutive drawings, to see the circle just drawn, but keep the eyes closed while the circles are being drawn. It is important to draw slowly and carefully.

**Results.** Measure the error in each circle by measuring in millimetres the distance between the beginning point and the ending point. Construct separate tables for the two series. Average the errors by groups of fives as shown in Table III. From these averages plot curves as shown in Fig. 7 and designate them as series I and II.

TABLE III

## EYES CLOSED

<u>1st 5</u>	<u>2nd 5</u>	<u>3rd 5</u>	<u>4th 5</u>	<u>5th 5</u>
4 mm.	4	5	10	9
8	5	9	6	7
6	5	6	7	4
4	4	5	5	5
4	5	5	1	6
<hr/>	<hr/>	<hr/>	<hr/>	<hr/>
5.2	4.6	6.0	5.8	6.2

## EYES OPEN BETWEEN TRIALS

5	2	2	2	0
5	4	2	4	3
6	3	6	3	1
4	0	2	0	1
3	2	2	0	1
<hr/>	<hr/>	<hr/>	<hr/>	<hr/>
4.6	2.2	2.8	1.8	1.2

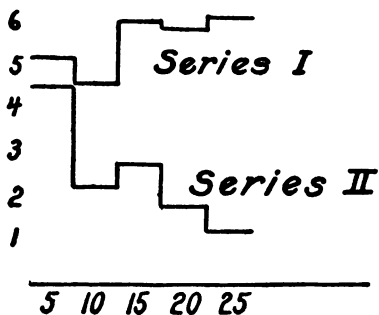


FIG. 7.

1. How do these series compare? What inference would you make with regard to learning with the knowledge of

one's progress as compared with learning without the knowledge of one's progress?

2. Should written work and examination papers be returned to the pupils? Should the degree of success be indicated? What reason can you give for pointing out the commendable as well as the erroneous points?

## CHAPTER VII

### THE PROGRESS OF LEARNING (CONTINUED)

**Problem.** In the experiments performed thus far the learning process consisted mainly in the formation of motor and perceptual coördinations. In the following experiment the learning will consist in the establishment of associations between two classes of visual symbols, both of which are perfectly familiar in themselves. The motor coördinations to express these symbols are also well established.

The specific problems are (a) to study the progress of learning in this new field and to compare it with the preceding type, (b) to find further factors which influence the rapidity of learning, such as the length of different periods of work and of different periods of rest, mental and physical conditions, etc. Incidentally we shall also obtain data on the transference of training, which will be used later.

**The Material** is supplied in the following pages. It consists of sets of pages headed with an imitation type-

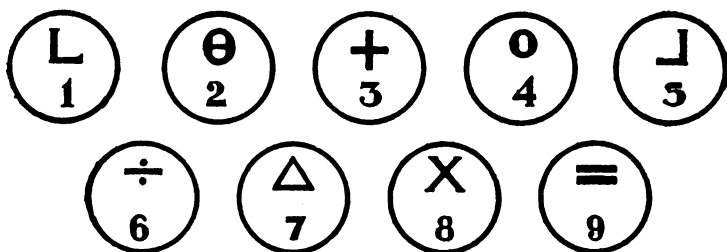
writer key-board.<sup>1</sup> Each letter of the alphabet is enclosed with a number in a circle. Below this "key-board" is the reading matter which is to be transcribed. This reading matter is different on the various pages.

**Procedure.** The task of the experiment consists in substituting the numbers for the letters in the spaces below. In order to obtain data in regard to the influence of intervals and lengths of work periods, it is necessary to divide the class into three equal groups.<sup>2</sup> One group should work for ten minutes at a time twice a day with an interval of at least five hours between the two periods. The second group should work for twenty minutes once a day, and the third group should work for forty minutes every other day. Each person should continue the work for six days. The group working every other day should work on the first, third, and fifth day. The total time in each group will be 120 minutes. The periods of work should be as nearly as possible at the same time of the day. Record in the proper places in the margin the date and time of day. No effort should be made during the intervening intervals to memorize the numbers and their letters. Do not leave blank spaces between the words in making the substitutions. Begin a new line for each line of print, always using the line of spaces opposite the line of print. In case of those letters for which two digits must be written, for example 18, both digits should be

<sup>1</sup> This type of substitution test was originally devised several years ago by Jastrow.

<sup>2</sup> Each group should contain at least ten persons. If the class is small it had better be divided into two groups only.

placed in one square. Work as rapidly as you can without making errors. Do not stop to correct errors if you make any. Have a watch on the table before you and make a check mark at the end of every five minutes. In order that this may be done with as little disturbance as possible, begin work when the minute hand is on a number. After each period of work record any observations that may bear upon the experiment. Note your general mental and physical condition. Note in particular during the course of the learning (a) the time when you know the first numbers without consulting the key-board, (b) the time when the first complete words can be written without consulting the key-board, and (c) the time when you know all or practically all substitutions.



84,976					
79,821					
63,442					
21,629					
57,183					
32,761					
95,146					
28,349					
73,862					
91,563					

In order to obtain data on the transference of practice, perform the following test before undertaking the above learning. Substitute as quickly as you can the symbols for the numbers on page 50. Record the exact length of time required to do this. After completing the regular substitution experiment repeat the same test using the material on page 68. Record the time. Preserve these "before" and "after" tests for use in a later chapter.





his hearers "be it ever so homely"). First among the causes of failure at the University, I should be inclined to place, "neglect of health." Young men are seldom aware how easily the brain may be overtasked, how delicate and sensitive this organ is in many individuals; they are apt to think they can do what others do; they work the mind and the body at the same time—when they begin to fail they only increase the effort, and nothing can be more foolish than this. They do not understand how to manage themselves, as the phrase is; the common rules

O 1	V 2	C 3	F 4	I 5	K 6	B 7	M 8	T 9	X 10	E 11	W 12	N 13	H 14	G 15	L 16	D 17	J 18	S 19	R 20	U 21	Z 22	P 23	Y 24	A 25	Q 26
of diet and exercise are hardly																									
thought of by them. "I can																									
work so much better at night"																									
is the constant reply to the																									
physician or elder friend who																									
remonstrates; and they are																									
apt to be assured that no																									
practice which is pleasant to																									
them can ever be injurious to																									
health. They find the memory																									

fail, the head no longer clear,
the interest in study flags;
and they attribute these
symptoms to some mysterious
cause with which they have
nothing to do. Will they hear
the words of the Apostle?
"He that striveth for masteries
is temperate in all things":
yet it is a more subtle kind
of training than that of the
athlete, in which they must
exercise themselves, a
training which regulates and
strengthens body and mind at
once. Again let them listen to
the words of St. Paul,
"Wherefore whether we eat
or drink, let us do all to the
glory of God." The care of his

O 1	V 2	C 3	F 4	I 5	K 6	B 7	M 8	T 9	X 10	E 11	W 12	N 13	H 14	G 15	L 16	D 17	J 18	S 19	R 20	U 21	Z 22	P 23	Y 24	A 25	Q 26
own health and morals is the																									
greatest trust which is com-																									
mitted to a young man; and																									
often and often the loss of																									
ability, the degeneracy of																									
character, the want of self-																									
control is due to his neglect																									
of them.																									
There are other ways in																									
which this want of self-																									

knowledge shows itself. Many
men have serious intellectual
defects which they never
attempt to cure, and there-
fore carry them into life
instead of leaving them
behind at school or college.
Let me take for example one
such defect—inaccuracy. A
student cannot write a few
sentences of Latin or Greek,
he cannot get through a simple
sum of arithmetic, without
making a slip at some stage
of the process, because he
loses his attention. Year after
year he goes on indulging this
slovenly habit of mind; the
remonstrances of teachers
are of no avail; he will not

Q <sub>1</sub>	V <sub>2</sub>	C <sub>3</sub>	F <sub>4</sub>	I <sub>5</sub>	K <sub>6</sub>	B <sub>7</sub>	M <sub>8</sub>	T <sub>9</sub>	X <sub>10</sub>	E <sub>11</sub>	W <sub>12</sub>	N <sub>13</sub>	H <sub>14</sub>	G <sub>15</sub>	L <sub>16</sub>	D <sub>17</sub>	J <sub>18</sub>	S <sub>19</sub>	R <sub>20</sub>	U <sub>21</sub>	Z <sub>22</sub>	P <sub>23</sub>	Y <sub>24</sub>	A <sub>25</sub>	Q <sub>26</sub>
<p>take the pains to be cured;  the inaccurate, desultory  knowledge of many things is  more acceptable to his mind  than the accurate knowledge  of a few, and so he grows up  and goes into life unfit for any  intellectual calling, unfit  for any business or profes-  sion. Then again there is</p>																									

another kind of inaccuracy  
which consists in ignorance  
of the first principles or  
beginnings of things; when  
the student has to go back  
not without difficulty, for  
there is always a painfulness  
and awkwardness in learning  
last what ought to have been  
learned first. We all know  
what is meant by a man being  
"a bad scholar," which to one  
who has studied Latin and  
Greek for ten or more years of  
his life is justly held to be a  
reproach. And there are bad  
scholars, not only among  
students of Latin and Greek,  
but in every department of  
knowledge, in Mathematics

which consists in ignorance

**of the first principles or**

**beginnings of things; when**

**the student has to go back**

**not without difficulty, for**

**there is always a painfulness**

## and awkwardness in learning

**last what ought to have been**

**learned first. We all know**

**what is meant by a man being**

**"a bad scholar," which to one**

**who has studied Latin and**

**Greek for ten or more years of**

**his life is justly held to be a**

**reproach. And there are bad**

**scholars, not only among**

**students of Latin and Greek,**

**but in every department of**

**knowledge, in Mathematics**



<div style="display: flex; flex-direction: row-reverse; justify-content: space-around; padding: 10px;"> <div style="text-align: center;">O 1</div> <div style="text-align: center;">V 2</div> <div style="text-align: center;">C 3</div> <div style="text-align: center;">F 4</div> <div style="text-align: center;">I 5</div> <div style="text-align: center;">K 6</div> <div style="text-align: center;">B 7</div> <div style="text-align: center;">M 8</div> </div> <div style="display: flex; flex-direction: row-reverse; justify-content: space-around; padding: 10px;"> <div style="text-align: center;">T 9</div> <div style="text-align: center;">X 10</div> <div style="text-align: center;">E 11</div> <div style="text-align: center;">W 12</div> <div style="text-align: center;">N 13</div> <div style="text-align: center;">H 14</div> <div style="text-align: center;">G 15</div> <div style="text-align: center;">L 16</div> <div style="text-align: center;">D 17</div> </div> <div style="display: flex; flex-direction: row-reverse; justify-content: space-around; padding: 10px;"> <div style="text-align: center;">J 18</div> <div style="text-align: center;">S 19</div> <div style="text-align: center;">R 20</div> <div style="text-align: center;">U 21</div> <div style="text-align: center;">Z 22</div> <div style="text-align: center;">P 23</div> <div style="text-align: center;">Y 24</div> <div style="text-align: center;">A 25</div> <div style="text-align: center;">Q 26</div> </div>	<div style="display: flex;"> <div style="width: 30%; padding: 5px;"> as well as in Classics, in  Natural Science as well as in  Literature, in Law as well as  in History; there are  students who have no power  of thinking, no clear recol-  lection of what they have  read, no exact perception of  the meaning of words.  There is another intellect- </div> <div style="width: 70%; border: 1px solid black; height: 200px;"></div> </div>
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ual defect very common in
youth, yet also curable, if
not always by ourselves, at
any rate by the help of others
—"bad taste"—which takes
many forms both in speaking
and writing, when a person
talks about himself, when he
affects a style of language
unsuited to him, or to his age
and position, when he dis-
cusses authoritatively to
his elders, when he is always
asking questions, when his
words grate upon the feelings
of well-bred and sensible men
and women, then he is guilty
of bad taste. Egotism or con-
ceit is often the source of this
bad taste in conversation; it

O <sub>1</sub>	V <sub>2</sub>	C <sub>3</sub>	F <sub>4</sub>	I <sub>5</sub>	K <sub>6</sub>	B <sub>7</sub>	M <sub>8</sub>	T <sub>9</sub>	X <sub>10</sub>	E <sub>11</sub>	W <sub>12</sub>	N <sub>13</sub>	H <sub>14</sub>	G <sub>15</sub>	L <sub>16</sub>	D <sub>17</sub>	J <sub>18</sub>	S <sub>19</sub>	R <sub>20</sub>	U <sub>21</sub>	Z <sub>22</sub>	P <sub>23</sub>	Y <sub>24</sub>	A <sub>25</sub>	Q <sub>26</sub>
<p>may sometimes arise only from  simplicity and ignorance of  the world. There are natures  who are always dreaming of  full theatres, of audiences  hanging on their lips, who  would like to receive for all  their actions the accompany-  ing need of approbation. A  young person is about to make</p>																									

a speech—it is one of the most important things that he can do in life (and one of the most trying)—when many persons are listening to his words and he is a weak swimmer far out at sea; he has prepared what he is going to say, tricked out his oration with metaphors and figures of speech; he has seen himself speaking, not exactly in the looking-glass, but in the glass of his own mind; and lo! the result is a miserable failure. He has mistaken his own powers, he has struck a wrong note, pitched his speech in a false key. What can be more humiliating? Yet, perhaps, it is also the

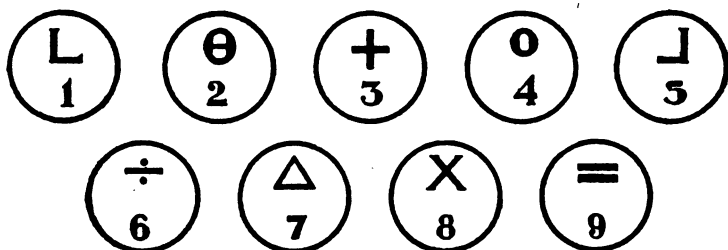
O 1	V 2	C 3	F 4	I 5	K 6	B 7	M 8
T 9	X 10	E 11	W 12	N 13	H 14	G 15	L 16
J 18	S 19	R 20	U 21	Z 22	P 23	Y 24	A 25
							Q 26
very	best	lesson	which	he	has		
ever	had	in	life.	Let	him	try	
again—	(there	was	one	who			
said	that	he	had	tried	at	many	
things	and	had	always	suc-			
ceeded	at	last).	Let	him	try		
again,	and	not	allow	himself			
by	a	little	innocent	merriment			
to	be	deprived	of	one	of	the	
greatest	and	most	useful				

[illegible]

Q <sub>1</sub>	V <sub>2</sub>	C <sub>3</sub>	F <sub>4</sub>	I <sub>5</sub>	K <sub>6</sub>	B <sub>7</sub>	M <sub>8</sub>	T <sub>9</sub>	X <sub>10</sub>	E <sub>11</sub>	W <sub>12</sub>	H <sub>13</sub>	G <sub>14</sub>	L <sub>15</sub>	D <sub>17</sub>	J <sub>18</sub>	S <sub>19</sub>	U <sub>21</sub>	P <sub>23</sub>	Y <sub>24</sub>	A <sub>25</sub>	Q <sub>26</sub>
hands. They attempt fine writing.																						
ing, which of all kinds of writing is the worst; they lose																						
the sense of proportion; they																						
deem anything which they																						
happen to know relevant to the																						
subject in hand. They pay																						
little or no attention to the																						
most important of all																						
principles of composition—																						

"logical connection."
They sometimes imitate the
language of famous writers,
such as Lord Macaulay or
Carlyle, and with a ludicrous
result, because they cease to
be themselves, and the
attempt even if it were worth
making cannot be sustained.
It was excellent advice that
was once given to a young
writer, "Always to blot the
finest passages of his own
writings"; and any one of us
will do well to regard with
suspicion any simile or
brilliant figure of speech,
which impairs the connection
or disturbs the proposition of
the whole. For in the whole





27,516					
33,821					
97,473					
62,978					
31,542					
17,143					
26,981					
35,724					
16,315					
14,923					

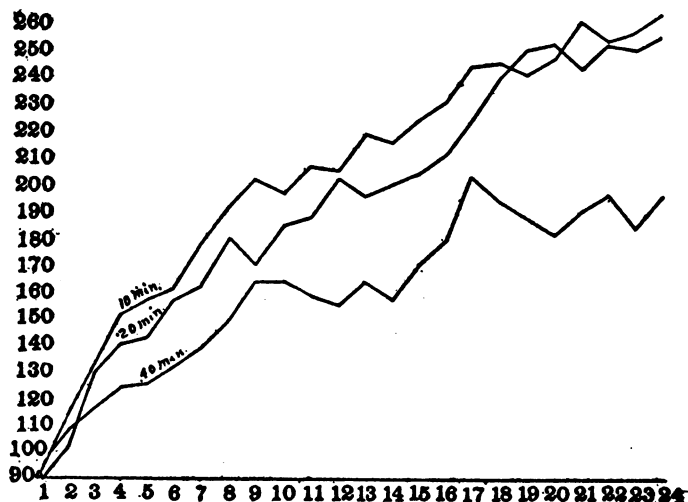


FIG. 8.

**Results.** Count the number of substitutions made during each five-minute period. Construct a table showing in different columns the date and time of day, the number of substitutions for each five-minute period, and brief introspective comments. Plot a curve in which the five-minute periods are represented on the horizontal line and the number of substitutions on the vertical line. See Fig. 8.

State your conclusions and discuss the following points:

1. Compare your curve with the curve obtained on the basis of the mirror tracings, particularly with regard to the rate of learning, rapid improvement at first and slower progress after that.

2. Does the present curve reveal any plateaus? How many?

3. Can you trace any connection between these stages and your introspective notes? For instance, between your general physical and mental condition and retardation or rapid learning. If your curve has distinct stages, notice particularly whether these coincide with the times, for example, when you first knew all the substitutions, or when you were able to write complete words and phrases without consulting the key-board.

4. What significance do the plateaus have in the learning process?

See Swift, *Mind in the Making*, pp. 206-218.

## CHAPTER VIII

### THE TRANSFERENCE OF TRAINING

**Problem.** The object of this experiment is to determine (a) to what extent, if at all, special training in one mental function improves other mental functions, and (b) to find some of the factors in such transference.<sup>1</sup>

**The Material** for this experiment is supplied on the following pages. Do not read or examine any of it until you are ready to use it, and then concern yourself only with that portion of it which you are about to use. In order to insure this condition, cover with a sheet of paper all material which is not used at the time.

**Procedure.** The usual method of determining by experiment the transference of training is to test a variety of mental functions, then to undertake a long course of training in one specific direction and finally to test again the same functions as were tested before the training. The

<sup>1</sup>The problems involved in the transference of training are usually discussed in educational literature under the heading of formal discipline, which is the doctrine that the mental discipline gained in the pursuance of school studies improves one's ability to perform other activities.

long practice course is called the training series, and the short tests performed before and after the practice are called the test series, or end tests.

In this experiment the test series consists of:

- a. A test of immediate auditory memory.
- b. Learning French vocabulary.
- c. Memorizing a group of ten syllables.
- d. Memorizing a stanza of poetry.

The training series consists in learning Italian vocabulary.

Proceed as follows:

a. The span of immediate auditory memory is to be tested in the same manner as in Chapter I, except that the following groups of letters are to be used instead of words. These groups should be read to the class at the rate of one letter per second, reading one group at a time and presenting the groups in order of size, from the smallest to the largest. After a group has been read the class writes down immediately all the letters remembered of that group and in the order in which they were presented.

l p k r

b s y g n

k f c q m d

h b n f t v x

l p r d m h c k

q w f r b h p m t

d l z n q j s v r f

b. Look through the list of French words below to see if you already know any of the words. Strike out those you know and enough others to leave only ten words. If none are familiar strike out the last five words. Then learn the English equivalents of these ten. Record the exact time in minutes and seconds required for the learning. Consider them learned as soon as you are able to give the English equivalents upon seeing the French words. Have a piece of paper at hand to cover the English words to find out whether you are able to do this.

chainage	survey
eveque	bishop
verbeux	verbose
rivage	shore
delit	offence
appui	support
semelle	foot
voiture	vehicle
mordre	bite
boutis	rooting
gacher	temper
galbe	outline
reveur	dreamer
trochet	cluster
ressui	lair

c. Memorize the following stanza of poetry. Record the exact time required. Consider it memorized as soon as you are able to repeat it without consulting the text.

From rocky cleft the torrent dashes;  
 Down, down he comes with thunder-shock;  
 The sturdy oak beneath him crashes,  
 And after rolls the loosened rock.  
 Amazed, o'erjoyed, with awe and wonder  
 The traveller stops and gazes round;  
 He hears the all-pervading thunder,  
 But cannot tell from whence the sound.

c. Memorize the ten syllables below so that you are able to repeat them from memory in the correct order. Record the time.

dut  
 nof  
 tep  
 min  
 rus  
 nir  
 len  
 zat  
 sim  
 pez

The training series consists of 180 Italian words and their English equivalents. They are divided into six groups of thirty words each. You are to learn the English equivalents in the same manner as the French vocabulary. Memorize one group a day. Record the time. Do the learning as nearly as possible at the same time of the day on six successive days. After the completion of this practice, repeat the tests performed before the training, using, however, the new material provided on later pages.

## I

acca	zero
cuoio	leather
accio	that
costa	rib
acqua	with
destro	skilful
alla	market
ne	thence
ballo	dance
ermo	desert
bere	drink
fetta	bit
caffo	add
tuffo	ruin
gabbo	jeer
carda	town
quatto	still
cambo	truck
acre	sour
raja	turnip
rilevo	crumbs
uria	omen
ritrorso	stubborn
everse	ruined
falda	plait
elmo	helm
dolo	fraud
fin	until
disfetto	affronts
citta	town



## II

affare	business
battello	vessel
agio	comfort
lana	wool
ala	wing
legnoso	woody
balia	judge
majo	tree
beffa	joke
marra	spade
botte	tub
talpa	mole
calco	drawing
otta	hour
prezzo	prize
conto	prudent
raggio	ray
cardo	thistle
elce	oak
scuro	dark
tale	like
ritto	upright
scalzo	naked
mezzo	half
monco	maimed
lucco	gown
lira	harp
omo	man
libbra	pound
conti	accounts

## III

fieno	hay
mazzo	bunch
bagno	bath
fitto	thick
pesca	sport
mena	plot
berza	skin
miglio	mile
flato	gust
bianco	white
miro	strange
fondo	land
blando	soft
frego	dash
gaffo	stupid
brama	wish
frutta	dessert
mosca	fly
butima	crowd
nano	dwarf
fuoco	fire
gamba	leg
nece	death
caccia	hunt
gatta	cat
netto	clean
caldo	hot
guida	leader
ogni	every
nuto	sign

## IV

nord	north
prode	bold
zana	basket
lasso	error
dazio	tax
prova	trial
degno	worthy
rame	copper
burla	joke
desto	brisk
refe	thread
lena	breath
dicace	glib
legna	fuel
remo	oar
dolce	sweet
letto	bed
saldo	firm
doge	captain
scolio	note
arbusto	shrub
lino	flax
scorso	error
dorado	golden
lode	praise
seno	breast
dosso	back
lucro	gain
torvo	grim
stufa	stove

## V

fune	rope
imo	deep
calze	stockings
orzo	barley
incauto	careless
uscio	door
carta	paper
intacto	complete
caso	accident
carne	meat
abbisso	gulf
pigro	idle
pegno	pledge
manto	much
mastice	glue
vinto	vanquished
barba	uncle
foggia	fashion
gita	journey
inno	hymn
canotto	ship
zolla	clod
corsa	run
lento	slow
guerra	war
storta	retort
nodo	knot
sponda	brink
bardo	poet
sabbia	sand

## VI

estro	genius
lume	light
esile	thin
tutto	all
lutto	grief
vallo	fence
mosca	fly
gambo	stock
ferita	cut
eburnio	ivory
smalto	enamel
vispo	quick
zuffa	fight
manso	tame
mastio	hinge
torto	wrong
bacio	kiss
finche	until
giorno	day
lordo	awkward
latte	milk
vezzi	charms
sugo	sap
gioco	trick
grido	cry
stima	esteem
neve	snow
sommo	top
gia	once
rotto	broken

Repeat the end tests using the following material:

a. Immediate auditory memory.

l k b h  
g l d s p  
f b w k n t  
y n c r d h j  
z q t n d r k v  
h j n x q d f m b  
c m s t v r b h p q

b. French vocabulary. Again cross out all the words you know and enough others to leave only ten words.

tuyau	tube
pourchas	pursuit
liste	band
paquis	pasture
colon	farmer
sparte	broom
ecueil	rock
houle	surge
moellon	sandstone
tamis	sieve
roupille	jacket
autan	wind
calcet	mast-head
curet	skin
filon	thief

## c. Stanza of poetry.

And, as the boy, with hopeless longing—  
 When stolen freedom yields no rest,  
 But home-thoughts to his heart keep thronging—  
 Flies to his injured mother's breast;  
 So Music has the power to charm us,  
 When turned from Nature's simple truth;  
 From cold and foreign ways to warn us  
 With the old feelings of our youth.

## d. Syllables.

nop  
 tud  
 dal  
 ros  
 mac  
 biz  
 jip  
 lor  
 fip  
 ruv

**Results.** Construct a table similar to Table IV, showing the learning times of the different groups of the training series, and of the different test series. Calculate the percentage of improvement in the training series by comparing the last day's record with the first day's record. Similarly, calculate the percentage of difference between the tests after the training and before the training.

TABLE IV

## RECORD OF ONE INDIVIDUAL

	End Tests Time Before	Training Series Time for Each Group	End Tests Time After	Percentage Gain or Loss
French.....	4 min.	1 20 min.	2 $\frac{3}{4}$ min.	+ 31
Poetry.....	7 min.	2 20 min.	5 min.	+ 29
Syllables.....	5 min.	3 16 min.	2 $\frac{1}{2}$ min.	+ 50
Memory Span .....	6 letters	4 15 min.	6 letters	0
		5 12 min.		
		6 12 min.		

The improvement in the second end tests is not entirely due to transference from the training series, but is due in a small measure to the benefit derived from the first end tests. This is shown by performing the end tests on a group of individuals with an interval of one week between the two tests and *without* taking the training tests. A test performed in this manner with eleven individuals showed an average improvement of 5 per cent. in learning French vocabulary and of 10 per cent. in learning poetry, and with twenty-eight subjects the improvement in learning syllables was 2 per cent. These percentages must be subtracted from the improvement in the regular experiment in order to obtain the amount of improvement due to transference.

Turn to the experiment in Chapter VII and compute the percentage of improvement in the end tests, namely in the substitution of symbols for numbers. Find also the percentage of improvement in the training series itself and compare it with the improvement in the end tests. Twenty-nine persons doing the end tests without the training series showed a gain of 4 per cent., which must be



deducted from the percentage of improvement shown by the subjects who took the training series.

Turn to Chapter VI and calculate the percentage of gain in time and errors in the two tracings made with the left hand. Compare this with the improvement in the practice of the right hand.<sup>1</sup> The records of twelve subjects showed that the left hand made 90 per cent. as much improvement as the right hand.<sup>2</sup>

Questions:

1. Which experiments in the end tests are most like and which least like the training series? Which show the largest amount of improvement? What general principle would you formulate?

2. In general how much improvement is transferred?

3. In the light of your results discuss this statement: "A change in one function alters any other only in so far as the two functions have as factors identical elements." (Thorndike, *Educational Psychology*, First Edition, p. 80.)

4. What bearing have these experimental results upon the question of mental discipline of school studies? Would training derived from one study help in the pursuit of others? If so, to what extent?

For further practical exercises see Thorndike, *Principles of Teaching*, 249-256; O'Shea, *Education as Adjustment*, Chapters 13 and 14.

<sup>1</sup> This type of transference of practice of one organ of the body to its bilaterally symmetrical organ is called cross-education. Its bearing upon the whole problem of transference among mental functions is only indirect.

<sup>2</sup> Starch, *Psych. Bulletin*, 7, 1910, 20-23.

TABLE V

PERCENTAGE OF GAIN IN END TESTS (30 OBSERVERS). TRAINING  
SERIES CONTINUED ONE WEEK

	French	Poetry	Syllables	Memory Span
1.....	31	29	50	0
2.....	20	17	53	0
3.....	18	9	50	0
4.....	..	12	25	0
5.....	7	17	70	0
6.....	50	14	62	14
7.....	11	..	44	0
8.....	10	29	75	-12
9.....	-22	38	0	0
10.....	32	69	48	0
11.....	45	50	48	0
12.....	20	28	18	0
13.....	35	40	20	0
14.....	9	20	15	0
15.....	6	12	14	0
16.....	17	5	20	0
17.....	14	21	7	0
18.....	8	4	-3	0
19.....	3	3	5	0
20.....	-26	25	20	0
21.....	26	21	25	-14
22.....	21	- 7	39	17
23.....	23	4	16	0
24.....	-25	16	13	0
25.....	- 4	20	10	0
26.....	30	23	- 4	0
27.....	-11	- 7	25	0
28.....	27	3	16	0
29.....	33	18	27	0
30.....	-24	8	55	17
	—	—	—	—
Average....	13	17	29	1

## CHAPTER IX

### ASSOCIATION

#### 1. The General Law of Association

THE law of association simply stated is this, Things<sup>1</sup> experienced together tend to recur together. The applications of this law to teaching are very obvious and very wide. They may be summed up under two principles, "Put together what you wish to have go together," and "Reward good impulses."<sup>2</sup>

The force of the law of association may be demonstrated very simply in this manner: Find the number of seconds required to repeat the alphabet as quickly as possible. Next find the time required to repeat the alphabet backwards. Explain the difference.

In the next experiment commit to memory the seven Spanish words printed below in Group I. While doing this keep the English equivalents covered with a piece of paper. Always repeat the words in order from the top of the column. Then cover the Spanish list and memorize the English words in their order. After you have learned both lists lay the book aside and find the time it will

<sup>1</sup> That is, ideas, mental states or processes.

<sup>2</sup> Thorndike, *Principles of Teaching*, p. 110.

take you to recall from memory the Spanish words in their order and the correct English equivalent of each. While you are learning do not compare the two lists.

Memorize the words in the second group, but in this case read the Spanish word and the English equivalent together. As soon as you know them, lay the book aside and find the time required to recall the foreign words and their meanings. Explain the difference in time between the recalling of the two groups.

## GROUP I

lutea	oriele
molleta	biscuit
poder	power
despensa	pantry
elenco	catalogue
conata	effort
obra	work

## GROUP II

tenue	thin
vera	edge
hondon	bottom
redro	behind
desvan	garret
dedo	finger
lecho	couch

TABLE VI

TABLE OF NINETEEN PERSONS, SHOWING THE TIME IN SECONDS OF  
RECALLING THE TWO GROUPS

	Group I	Group II
1.....	25"	10"
2.....	17"	5"
3.....	16"	9"
4.....	50"	10"
5.....	56"	6"
6.....	30"	10"
7.....	35"	10"
8.....	25"	15"
9.....	40"	9"
10.....	20"	6"
11.....	50"	5"
12.....	22"	12"
13.....	45"	35"
14.....	53"	18"
15.....	45"	18"
16.....	40"	20"
17.....	30"	8"
18.....	55"	30"
19.....	20"	6"
Average.....	35.5"	13"

## 2. Specific Laws of Association

**Problem.** The object is to demonstrate the laws according to which ideas or mental states are associated. Why does a given idea bring to mind a certain idea rather than some other? For example, why does "December 25th" bring to mind "Christmas" rather than "President Johnson's proclamation of pardon"? What determines which one of a score of possible connections shall be made?

**The Material** is supplied on the following ten pages. It is imperative that you should not examine it except under strict experimental conditions. Therefore, do not turn to it until you are ready to do the experiment. The material is composed of syllables and numbers. Each series is composed of ten pairs of syllables and numbers printed side by side. Take a sheet of paper, at least twelve centimetres square, and cut crosswise in the centre of it a rectangular aperture, 5 mm. by 4 cm. This will serve as a simple means of exposing the pairs of syllables and numbers for uniform intervals of time.

**Procedure.** Turn to Series I and immediately lay the sheet of paper over the page so that the aperture exposes nothing but the words "Series I." Each pair in the series is to be exposed for three seconds. The time is indicated by your partner, who taps on the table every three seconds. Take hold of the sheet of paper with the right hand and at the first tap slide it down to expose the first pair, at the next tap slide it down to expose the second pair, and so on through the entire series. Give your entire attention to the particular pair exposed. Pronounce to yourself both the syllable and the number. As soon as you have finished, slide the sheet of paper down and expose the set of syllables (test series) on the lower half of the page. Be sure, however, not to uncover any part of the upper series (stimulus series). These syllables are the same ones used in the stimulus series, but they are arranged in different order. Your partner again taps at intervals of three seconds. Begin at the top and write

opposite each syllable the number that comes to your mind as the one seen with it in the stimulus series. Pass to the next syllable at the next tap, and so on. If no number is recalled leave the space blank. Work through the other nine series in exactly the same manner. Allow an interval of at least two minutes between the successive series. Before working out the results your partner should go through the experiment also.





## SERIES I

var	37
mup	95
tib	31
sov	57
raz	89
mup	95
vej	63
zik	17
tev	40
kes	52

vej  
sov  
mup  
var  
tib  
raz  
tev  
zik  
kes



## SERIES II

rad	43
guf	21
dut	25
nib	27
WAP	53
cag	86
taz	97
ber	34
fon	69
tim	24

taz  
fon  
tim  
cag  
wap  
dut  
rad  
ber  
nib  
guf



## SERIES III

rol	58
kuf	73
jer	46
kus	65
pif	39
geb	64
mez	15
fex	35
jer	46
fil	79

kuf  
 pif  
 fex  
 jer  
 fil  
 rol  
 kus  
 geb  
 mez



SERIES IV

ren	67
sur	49
kep	85
luf	26
dar	92
kam	33
tuc	28
sor	51
LOD	68
zan	32

ren  
 kep  
 tuc  
 sur  
 zan  
 lod  
 luf  
 kam  
 sor  
 dar





SERIES V

bal	98
hon	76
ker	23
liu	68
rad	55
hus	19
pex	83
liu	68
rul	47
fos	94

hon  
rad  
ker  
fos  
bal  
rul  
liu  
pex  
hus

UNIVERSITY OF  
CALIFORNIA

SERIES VI

mep	36
vib	78
lat	90
vul	18
zed	29
kas	54
REN	72
dov	88
cer	93
tis	60

cer  
ren  
zed  
lat  
mep  
tis  
dov  
kas  
vul  
vib



## SERIES VII

mol	91
gir	20
lez	66
pof	38
reb .	16
lem	99
zat	48
neb	50
pof	38
tid	25

mol  
lez  
reb  
zat  
pof  
tid  
neb  
lem  
gir



## SERIES VIII

<b>cak</b>	<b>81</b>
<b>mun</b>	<b>56</b>
<b>KEX</b>	<b>13</b>
<b>gam</b>	<b>96</b>
<b>jik</b>	<b>30</b>
<b>hun</b>	<b>59</b>
<b>dut</b>	<b>74</b>
<b>seb</b>	<b>33</b>
<b>bic</b>	<b>42</b>
<b>rel</b>	<b>11</b>

**jik**  
**kex**  
**cak**  
**hun**  
**seb**  
**rel**  
**mun**  
**gam**  
**dut**  
**bic**





SERIES IX

dak	14
vof	70
zib	82
lis	44
med	71
mib	62
vof	70
sim	56
len	34
ner	27

mib  
dak  
ner  
sim  
vof  
med  
lis  
zib  
len



## 110 EXPERIMENTS IN EDUCATIONAL PSYCHOLOGY

### SERIES X

nof	45
rus	80
cem	64
fop	37
mig	29
lan	87
LOR	53
tal	16
bax	42
ges	61

nof  
cem  
mig  
lor  
bax  
ges  
tal  
lan  
fop  
rus



## 112 EXPERIMENTS IN EDUCATIONAL PSYCHOLOGY

**Results.** The purpose of the experiment is to demonstrate the four laws of association.

a. *Primacy.* Other things being equal, the first association is most apt to be recalled.

b. *Frequency.* Other things being equal, the most frequent association is most apt to be recalled. This is illustrated in series 1, 3, 5, 7, 9, in which one syllable occurs twice with the same number.

c. *Intensity.* Other things being equal, the most intense or most vivid association is most apt to be recalled. This is illustrated in series 2, 4, 6, 8, and 10, in which one pair is printed in much larger type.

d. *Recency.* Other things being equal, the most recent association is most apt to be recalled. Primacy and recency are illustrated in each series by the first and last pairs.

Construct a table to show the number and percentage of correct associations. Follow Table VII as model. The results of Series I or any other series should not be counted if they were vitiated by incorrect performance of the experiment.

TABLE VII

In series I, correct associations.....	3
by primacy.....	1
by recency.....	1
miscellaneous.....	1
In series II, correct associations.....	2
by recency.....	1
by intensity.....	1, etc.
Total possible associations by primacy.....	10
" " " frequency.....	5
" " " intensity.....	5
" " " recency.....	10
" " " miscellaneous.....	65

Percentage of correct associations made in each case:

by primacy,	5 out of 10 possible ones.....	50%
by frequency,	3 out of 5 possible ones.....	60%
by intensity,	4 out of 5 possible ones.....	80%
by recency,	4 out of 10 possible ones.....	40%
miscellaneous,	14 out of 65 possible ones.....	21%

TABLE VIII

TABLE OF RESULTS OF TWENTY-EIGHT PERSONS

	Primacy	Frequency	Intensity	Recency	Miscellaneous
1.....	5	2	1	7	12
2.....	6	3	1	4	22
3.....	10	1	0	4	21
4.....	0	1	2	3	13
5.....	8	3	2	6	9
6.....	6	0	2	2	6
7.....	8	1	4	5	18
8.....	2	0	1	6	1
9.....	4	1	1	8	14
10.....	5	1	2	4	7
11.....	4	0	0	1	27
12.....	5	1	1	3	9
13.....	6	4	3	5	23
14.....	3	2	1	6	4
15.....	3	1	2	3	17
16.....	2	3	1	3	22
17.....	6	2	3	3	15
18.....	7	0	5	6	0
19.....	6	1	3	0	16
20.....	4	3	1	2	23
21.....	6	3	0	4	28
22.....	4	1	5	6	14
23.....	3	1	3	5	12
24.....	2	1	0	2	15
25.....	7	3	3	6	29
26.....	4	0	1	5	14
27.....	8	1	1	3	27
28.....	9	2	0	0	11
Average..	5.1 51%	1.5 30%	1.75 35%	4.0 40%	15.3 24%

## 114 EXPERIMENTS IN EDUCATIONAL PSYCHOLOGY

### Questions:

1. Give several illustrations from your own experience in school in which the laws of association were applied correctly. Several in which they were applied incorrectly.
2. How would the laws of association apply to the learning of correct grammatical forms? Spelling? Paradigms? Dates of history?

For a very excellent list of questions and specific exercises, see Thorndike, *Principles of Teaching*, pp. 112-123.

## CHAPTER X

### APPERCEPTION

**APPERCEPTION** is the "manner in which we receive a thing into our minds" (James). It includes all the processes by which we read meaning into sense impressions. One person calls an object a useless stone; another calls it a fossil of the carboniferous age. The two persons receive the object differently, they give different meanings to the same sense impressions. Each gives that particular interpretation which is most in accord with his particular mental make-up.

**The General Problem** of the experiments in this chapter is to illustrate the facts of apperception, that the mind always endeavors to give some meaning to every incoming impression, whether new or old, and to find some factors which determine what meaning shall be given to a particular impression.

1. To demonstrate the meaning tendency of the mind.

a. Turn to the ten ink blots and write into your notebook the first thing that each one suggests or represents to you, that is, the first meaning which naturally comes to you as you see each one. Do not study them or try to force a meaning into them.





1



2



3.

FIGS. 9, 10, 11.



4



5



6

FIGS. 12, 13, 14.



7



8



9



10

FIGS. 15, 16, 17, 18.

The experiment clearly demonstrates that the mind normally attempts to interpret every sensation. It tries to give meaning even to those impressions which are entirely without meaning and unlike anything previously experienced. The ink blots are in themselves without significance, and were not made with the intention of representing anything. The meaning you give to each is entirely imposed upon it. The mind is persistent in giving meaning to its sensations because meaningless things have no value or significance. The mental development of a child is largely a development of apperception.

b. Turn to the ten syllables given below. Write in your note-book what each one reminds you of or suggests to you.

nof  
cem  
mig  
lor  
bax  
ges  
tal  
lan  
fip  
rus

Here again the same fact is illustrated. The mind gives meaning even to the meaningless. These three-letter syllables do not constitute words or symbols, yet each one almost without exception stirs up some association or other and forthwith it has meaning.

c. As soon as a meaning has been given to impressions they at once become definite according to the particular meaning imposed. Find the frogs in Fig. 19, and notice



*By permission of Century Company.*

FIG. 19.

that as soon as you have found them the blur springs into definite outline. The external stimulus is moulded according to the meaning given.

d. In the developed adult mind the interpretative tendency is so dominant that the attention is primarily upon the meaning aspect, to the neglect of the actual sense stimuli upon which the meaning is based. Only the slightest hint needs to be given to make the mind see this or that particular object. The mind, as it were, supplies the necessary material to fill out the picture. To demonstrate this point, ask an assistant to set the book at a distance of twenty or twenty-five feet from you to show Fig. 21, on page 130.<sup>1</sup> Do not look it up yourself, as it is

<sup>1</sup>The experiment can best be performed by the entire class simultaneously, in which case the instructor in charge should place

important that you should not see the figure at close range until after the experiment. Make a duplicate freehand drawing of the figure thus shown. Put in all the lines and details that you see.

Compare your drawing with the figure in the book. Explain the difference. The mind reads meaning into sense impressions, supplies details and makes the external stimulus conform to the apperceived meaning. Fig. 26, on page 183, is a typical sketch drawn under experimental conditions.

2. The particular meaning given to a group of sensations is determined by the previous experiences of the individual.

a. Compare your record of the ink-blot test with that of one other person. For this purpose make a table numbering in the first column from 1 to 10, in the second column place opposite each number the meaning you gave to each blot, and in the third the meanings given by the other person.

b. Construct a similar table for the syllable test. In addition, state so far as you can why each syllable reminds you of this or that word or object. Obtain similar statements from the person whose record you have. These introspective statements show, however superficially, that the same impressions are apperceived differently by different persons because of different past experiences.

the book at the required distance. No one in the class should be nearer than twenty feet.

c. The richness of the meaning or completeness of the meaning which we give to a sense impression depends upon the number and richness of the associations connected with that sense impression. After each one of the following words write the names, or simply a check mark, of as many different actual situations or particular experiences as you can recall, in which each was involved: 1. Midas; 2. Flatiron Building; 3. Railroad; 4. Toboggan; 5. Poetry; 6. Psychic Medium; 7. Skeeing; 8. Telescope; 9. The "L"; 10. Grain Binder.<sup>1</sup> See for illustration Table IX. If any word calls up many associations, stop with ten.

TABLE IX

1. Midas . . . . .
2. Flatiron Building . . . . .
3. Railroad . . . . .
4. Toboggan . . . . .
5. Poetry . . . . .
6. Psychic Medium . . . . .
7. Skееing . . . . .
8. Telescope . . . . .
9. The "L" . . . . .
10. Grain Binder . . . . .

Represent your results in a curve. Put on the horizontal line the numbers of the words and on the vertical lines the numbers of associations. See Fig. 20.

d. The nature of our past experiences and associations, then, determines how we shall interpret and react to

<sup>1</sup> Of course very familiar concepts are bound up with such a wealth of associations that many are beyond recall and yet contribute to the significance of the concept. The words chosen for the text include some very familiar concepts and some very unfamiliar.

present stimuli. This entire system or range of acquired experiences is in general equivalent to the range of information which a given individual possesses. The total bulk of one's information or experience is sometimes called the "apperceptive mass." The Australian bushmen call a book "mussel" because it opens and shuts like a shell-fish. Their range of information did not include experiences with books.

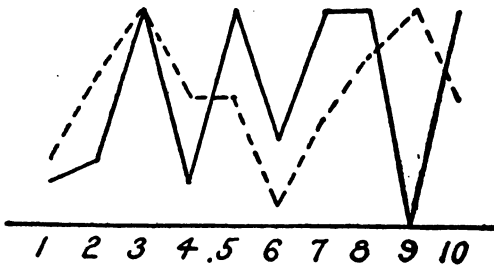


FIG. 20.

The following is designed as an information test.<sup>1</sup>

"Below are 100 words, phrases, or abbreviations, largely technical, which are designed to test the range of your information. Consider each one carefully, and place after it one of these four marks:

"(1) the mark D if you could define it as exactly as words are ordinarily defined in the dictionary.

"(2) the mark E if you could explain it well enough to give some idea of its meaning to one who is not familiar with it, though you could not give an exact definition that would satisfy an expert.

<sup>1</sup> From Whipple, Psych. Rev. 16, 1900, 347-351.



"(3) the mark F if the word is merely roughly familiar, so that you have only an indefinite idea of its meaning and could not use it intelligently.

"(4) the mark N if the word is entirely new and unknown to you.

ageratum	cleistogamous	infusoria	puer
amphioxus	cosmogony	intaglio	pyramidal tract
amphora	cotangent	Kepler's law	quadratics
annealed	dibble	kilogram	rococo
Anthony Wayne	dietetics	kinesthetic	R. S. V. P.
apocalypse	dryad	kinetic	scherzo
architrave	electrolysis	Les Misérables	semaphore
aujourd'hui	Elohim	linotype	simony
Babcock test	entrée	logos	spoils system
base-hit	Eocene	luff	Stoicism
Bernard Shaw	Euclid	Malthus' law	synecdoche
Bokhara	f-64	metacarpal	testudo
Braille	f. o. b.	midiron	tort
call-loan	gambit	Millet	trepine
calorie	gasket	mitosis	triangulation
cantilever	glycogen	morgen	trilobite
Caedmon	gneiss	nada	triple-expansion
catalepsy	golden section	natural selection	undistributed
cephalic index	guimpe	noi	Utopia [middle
ceramics	hedonism	ohm	vantage-in
chamfer	hemiptera	parallax	way-bill
Chartism	homiletics	peneplain	Weismannism
chlorine	hydraulic press	Pestalozzi	wigwag
chromosome	impetigo	Polonius	X-Ray
clearing-house	impressionism	pomology	Zionism

**Results.** a. Count the number of each class.

b. State the meaning briefly of all the words you marked F which are also marked F by one other person in the class. Make a comparative table.

3. The particular meaning given to a group of sensations is determined not only by the general mass of previous experiences but also by the particular system of past associations dominant in the mind at the time, that is, the meaning is determined by the *present setting of the mind*.

a. Turn to the following ten lists of skeleton words. Fill in the missing letters to make words. The number and the position of the letters to be supplied are indicated by the dashes. Take the groups in the order in which they are numbered. Work as rapidly as possible, and record the time required for each group. If a skeleton does not suggest the missing letters within a reasonably short time, say twenty to thirty seconds, leave it blank.

I

The following are miscellaneous nouns.

1. P - - er
2. N-m-
3. H-b-t
4. S-c -l
5. V-l-e
6. P-n
7. B- -k
8. St-e-t
9. -o-se
10. Gl-s-

II

The following are names of articles of dress.

1. Gl-v-
2. -at
3. T-e
4. P-n
5. C- -t
6. -o-l-r
7. B- - t-n
8. -e-ch- -f
9. Sh-e
10. C- -f

## III

The following are names of household furnishings.

1. C-a-r
2. L-m-
3. B-d
4. R- -k-r
5. T-b- -
6. C- -t-in
7. D- -ss-r
8. P-ct-re
9. D- -k
10. St-v-

## IV

The following are names of familiar fruits.

1. A- -le
2. C-e- -y
3. O-a-g-
4. Pl- -
5. L- - -n
6. B- -a-a
7. -pr- -ot
8. P-a-h
9. Gr-p-
10. P- -r

## V

The following are names of well-known American authors.

1. E- -rs-n
2. L-we- -
3. H- -m-s
4. R-l-y
5. B- -a-t
6. W-i- -i-r
7. C- -p-r
8. P- -
9. I-v-n-
10. V- -D-k-

## VI

The following are miscellaneous nouns.

1. Fl-o-
2. T-e-
3. W-te-
4. P-n- -l
5. N-m- -r
6. K- -f-
7. R-v-r
8. W-g- -
9. Sq- -r-
10. -n-m-l

VII

The following are names of  
pieces of American  
money.

1. P-nn-
2. N-c- -l
3. C- -t
4. Q-a-t-r
5. B- -l
6. D-m-
7. -o-l-r
8. S-lv-r
9. C- -p-r
10. G-ld

VIII

The following are names of  
familiar domestic  
animals.

1. -o-se
2. d-g
3. C-w
4. C- -f
5. S- -ep
6. -at
7. H-g
8. Chic- - -
9. D- -k
10. T- -k-y

IX

The following are names of  
university studies.

1. F-e-c-
2. L- - -n
3. H-s-or-
4. -th-cs
5. B-t-n-
6. G-rm- -
7. E-g- -s-
8. -n-t-my
9. P- -s-cs
10. Ge-l-g-

X

The following are names of  
American cities.

1. B- -t-n
2. N-w- -r-
3. Se- -tl-
4. Chic- - -
5. St -o- -s
6. D-n- -r
7. O- -h-
8. P-rt- -nd
9. B- -f- -o
10. -lb-n-

Find the average time required to do Groups I and VI and the average time for the other eight groups. How do they compare? Explain the difference.

In each group, except I and VI, a specific system of associations is made prominent at the outset; that is, the mind is "set" in a specific way, with the result that (a) the meanings of the skeletons arise much more rapidly and (b) they are in accord with the particular set of associations present. This point is demonstrated by the fact that twenty-two skeletons are alike. Yet in each group a different meaning arises according to the set of the mind. If you noticed during the experiment that any skeleton was like one you had in a preceding group, indicate which ones.

The ones alike are I 6 and II 4

I 9 and VIII 1

II 2 and VIII 6

II 5 and VII 3

II 6 and VII 7

II 7 and IX 1

II 10 and VIII 4

III 9 and VIII 9

IV 5 and IX 2

V 7 and VII 9

VIII 8 and X 4.

TABLE X

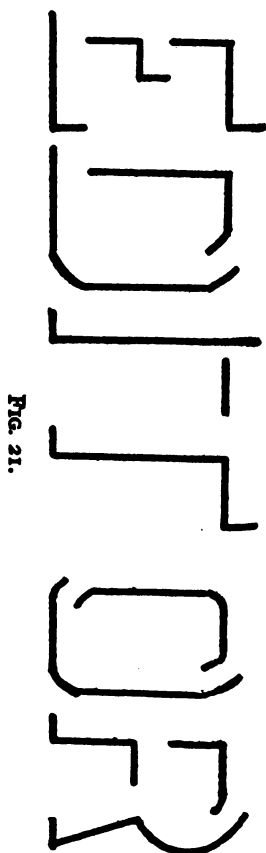
RECORDS FROM TWENTY-EIGHT PERSONS

	Av. of Groups I and VI	Av. of the other groups
1.....	1' 55"	23"
2.....	35"	22"
3.....	55"	24"
4.....	28"	24"
5.....	30"	8"
6.....	2' 35"	1' 18"
7.....	1' 10"	42"
8.....	2' 30"	51"
9.....	46"	30"
10.....	52"	28"
11.....	2' 30"	1' 1"
12.....	43"	30"
13.....	1' 45"	1' 20"
14.....	1' 22"	44"
15.....	32"	24"
16.....	37"	25"
17.....	2' 45"	1' 8"
18.....	32"	28"
19.....	1' 10"	40"
20.....	55"	25"
21.....	1' 52"	1' 15"
22.....	2' 30"	40"
23.....	40"	20"
24.....	1' 25"	36"
25.....	1' 15"	16"
26.....	27"	14"
27.....	55"	32"
28.....	55"	26"
Average.....	1' 15"	36"

b. Look for just an instant, not more than a second, at Fig. 22. Record what it represents. Then look at it for

several seconds and again record what you observe.  
Explain the results.

c. What is the "meaning" or suggestion of the follow-



ing phrases? It may be necessary to read each one  
several times.

- (1) Pas de lieu Rhône que nous.
- (2) Von der Vottei mit is.
- (3) Gui n'a beau dit, qui sabot dit, nid a beau dit elle.
- (4) Mein die Uhr onbiss Nüss'.

Both of these experiments demonstrate in different fields the fact that the meaning read into sensations depends upon the set of the mind. In case of Fig. 22 the

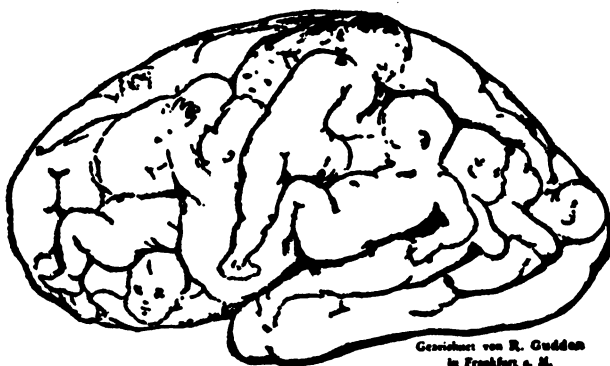


FIG. 22.

meaning suggested is "brain," and the outlines and convolutions are seen in accordance with it. In case of the foreign phrases the set of the mind is either "French" or "German," and you endeavor to give them meaning accordingly. The dominant set of associations makes it difficult to see or rather to hear the meaning of these "English" sounds.<sup>1</sup>

<sup>1</sup> If you have failed to discover the meanings you will now notice that the sounds are identical, or nearly so with

1. Paddle your own canoe.
2. Wonder what time it is.
3. Gin a body kiss a body need a body tell.
4. Mind your own business.



The principles of apperception have a very important application to teaching. First, link new information to the information, experiences, and associations which the learner already possesses. Second, prepare the proper apperceptive basis in the pupil for the reception of new material.

For practical exercises and applications to specific problems, see Thorndike, *Principles of Teaching*, pp. 44-50; O'Shea, *Education as Adjustment*, Chapter 12.

## CHAPTER XI

### ATTENTION

Two of the main problems of attention with which the teacher is constantly concerned are: How to secure the attention of pupils to the work in hand, and how to hold the attention after it has been secured. What are the laws of attracting attention, and what are the laws of sustaining attention?

1. **Laws of Attracting Attention.** These will be stated after the experiments have been performed. Proceed therefore at once to make the following tests.

**The Material** to be used consists of groups of words. Each group is to be seen for only five seconds. To insure this condition, the material for each experiment is printed on a separate leaf, so that only one group can be seen at a time. The interval of five seconds is to be indicated by your partner, who will tap on the table at the beginning and at the end of the interval. Have the book before you and be ready to turn the leaf at the first tap. Look at the words until your partner taps again. Then turn the book over and write into your note-book all the words that you remember having noticed. Designate them as

## **134 EXPERIMENTS IN EDUCATIONAL PSYCHOLOGY**

**Group I.** Do not attempt to memorize any of the words, but rather look passively at the whole group.

In this manner continue the experiment with the remaining eight groups. Have an intermission of at least one minute between the successive groups.

## GROUP I

term	cast	hang	look	WAIT
down	keep	CARE	draw	vein
sort	grow	bind	THAN	face
cold	PLAN	come	view	mark
suit	call	WORK	poor	evil



## GROUP II

bite	STAY	give	rise	have
stop	take	jerk	PICK	snap
play	wake	TRIM	this	from
COAT	pull	pain	bold	push
pour	hill	busy	BLOW	leaf



## GROUP III

blue	pray	<i>beat</i>	here	want
that	<i>pick</i>	rudè	time	your
zeal	damp	turn	<i>just</i>	with
tilt	fall	<i>iron</i>	once	yard
more	step	thou	lead	<i>find</i>





## GROUP IV

heir	<i>clad</i>	make	live	fold
<i>tell</i>	rear	reef	firm	wing
fire	hand	<i>rock</i>	will	yarn
form	mind	walk	<i>gold</i>	fear
part	like	<i>pass</i>	moat	room



## GROUP V

αγων	ημι	ανευ	send	νικη
ομως	pure	κυων	ζωη	αλλα
δορυ	λυπη	lark	καγω	χαρ
mule	απαξ	ωτις	βουτ	γυνη
υπερ	χιων	ατην	milk	αχει



## GROUP VI

επτα	wall	φημι	εωρα	δικη
αντι	υδωρ	τηκω	ισως	mode
πλεω	αστυ	lark	λεγω	αρμα
οπως	γενω	βιος	moon	μενω
αμφι	land	σως	ανηρ	σπαω



**GROUP VII**

**fare    good    hard    gray    home**





## GROUP VIII

what	hate	shot	gone	roll
seem	hope	gate	mean	hair



## GROUP IX

head	wood	hear	each	lime
gush	when	calf	some	chin
horn	comb	song	free	less
boat	hole	long	knot	cure
slow	coal	sick	lend	crow



**Results.** The four laws demonstrated above are:

a. The law of intensity. Other things being equal, the amount and degree of attention depends upon the intensity of the stimulus. Groups I and II contain each twenty-five words, of which five are printed in large capitals. These will arouse more intense sensations and consequently are more apt to be noticed.

b. The law of contrast. Other things being equal, the amount and degree of attention depends upon the contrast of the stimulus with other stimuli. Groups III and IV contain each twenty-five words, of which five are printed in italics.

c. The law of clearness or comprehension. Other things being equal, the amount and degree of attention depends upon the ease of apprehending the impressions, or upon the clearness of the impressions. Groups V and VI are composed of Greek words with the exception of five English words in each group. Because of the familiar or clear meaning of the English as compared with the Greek words, they are more apt to be noticed and remembered. We attend with difficulty to the meaningless or to the absolutely new.

d. The law of counter attractions. Other things being equal, the amount and degree of attention depends upon the absence of counter attractions. That is, the smaller the number of objects is, the greater are the chances that a given object will attract attention. In Group VII there are only five words, all of which will ordinarily be noticed in the allotted time. In Group VIII there are

ten words, of which usually not more than five will attract sufficient attention to be remembered. Hence the chances are about one in two that any particular word will be noticed. In Group IX, which contains twenty-five words, the chances are one in five that any given word will be noticed.

Construct a table like the following one:

TABLE XI

## Intensity. Groups I and II

8 of the 10 large words were noticed<sup>1</sup> . . . . . = 80%

4 of the 40 miscellaneous words were noticed . . . . = 10%

## Contrast. Groups III and IV

9 of the 10 words printed in italics were noticed . . = 90%

2 of the 40 miscellaneous words were noticed . . . . = 5%

## Clearness. Groups V and VI

6 of the 10 English words were noticed . . . . . = 60%

1 of the 40 Greek words was remembered . . . . . = 2½%

## Counter attraction. Groups VII, VIII, and IX

4 of the 5 in Group VII were noticed . . . . . = 80%

5 of the 10 in Group VIII were noticed . . . . . = 50%

4 of the 25 in Group IX were noticed . . . . . = 16%

<sup>1</sup> The word noticed in each case means of course that the words attracted sufficient attention to be remembered until they could be written down.

TABLE XII

## RECORDS OF TWELVE PERSONS

	Intensity	Contrast	Clear- ness	Miscella- neous	Counter attraction		
	Groups I, II	Groups III, IV	Groups V, VI	Groups I to VI	Groups VII, VIII, IX		
1.....	50%	60%	80%	7.5%	100%	50%	12%
2.....	50	30	100	7.5	100	70	24
3.....	0	80	90	7.5	100	60	24
4.....	50	100	60	7.5	100	60	20
5.....	30	60	60	4.	80	40	16
6.....	60	100	100	4.	100	50	20
7.....	20	30	70	12.	100	40	20
8.....	40	60	70	6.	100	30	20
9.....	60	90	70	7.5	100	40	20
10.....	10	30	70	12.	100	50	16
11.....	20	70	100	14.	100	30	16
12.....	70	70	90	7.5	100	40	12
Average...	38.5	65	80	8.1	98.5	46.7	18.5

2. **The Fluctuation or Shifting of the Attention.** Our attention shifts continuously from moment to moment. Even with great effort it is impossible to keep the attention focussed for more than a few seconds upon the same idea or object.

a. Look steadily at the central line in the "book" figure below. You will notice that the figure "flops" in and out. Part of the time it looks like a book open toward you, and part of the time like a book with its back toward you. Make a two minutes' record of these alternations. At the signal "now" from your partner, look steadily at the figure. Do not change your point of fixation. When the figure appears like a book open toward



you say "in." At the moment it shifts over so that the back of the "book" stands out toward you say "out," and so on for two minutes. Do not try to make the fig-

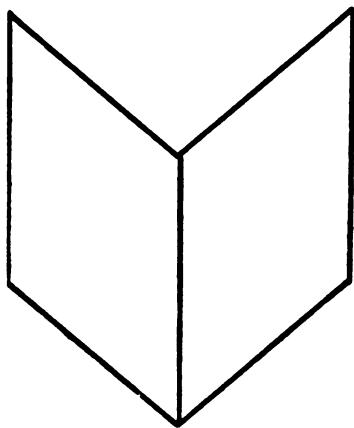


FIG. 23.

ure change, but allow the alternations to occur at their natural rate. Your partner follows the second-hand of his watch and records the position of the hand each time you say "in" or "out." The record will be similar to the following one:

In.....	15	23	30	38	47	57	5	14
Out.....	19	26	35	42	50	1	10	etc.

Compute the average length of the "in" and of the "out" periods separately.

TABLE XIII

RECORDS OF TWELVE PERSONS, SHOWING THE AVERAGE DURATION OF  
THE "IN" AND "OUT" PERIODS

	"In" periods	"Out" periods
1.....	4.4"	7.6"
2.....	5.1"	5.7"
3.....	8.2"	6.5"
4.....	3.0"	3.0"
5.....	3.2"	3.9"
6.....	5.2"	4.8"
7.....	3.0"	3.7"
8.....	6.9"	5.3"
9.....	2.0"	2.4"
10.....	5.0"	7.4"
11.....	3.2"	3.5"
12.....	4.0"	4.2"
Average.....	4.4"	4.8"

b. (1) Look at the figure below for two minutes and notice that your attention periodically wanders off to something else. As soon as you catch your attention off

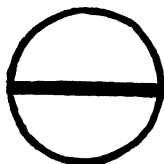


FIG. 24.

the figure, bring it back. Call out "now" each time you have to force your attention back to the figure. Your partner records the time in the same manner as in the preceding experiment. Calculate the average length of the periods.

(2) Look at the same figure for two minutes, but this

time try to work out in your mind the following questions about the figure: How long is the diameter of the circle? What is the width of the bar and of the circular line? What different things does the figure represent to you, or of what does it remind you? etc.

If your attention should shift to anything not connected with the figure call out "now" and your partner will keep a record as before. How does this test compare with the preceding record with regard to the number of times the attention shifted away from the problems connected with the figure?<sup>1</sup>

3. **Concentration of Attention.** Turn to Fig. 23 and repeat the experiment under 2 a. Take a two minutes' record in exactly the same manner, but in this experiment

TABLE XIV

RECORDS OF TEN PERSONS, SHOWING THE NUMBER OF TIMES THE ATTENTION SHIFTED FROM THE FIGURE UNDER THE CONDITIONS OF EXPERIMENT b (1) AND b (2)

	b (1)	b (2)
1.....	25 times	5 times
2.....	15	10
3.....	12	5
4.....	4	0
5.....	9	3
6.....	7	3
7.....	6	0
8.....	7	4
9.....	8	0
10.....	6	9
Average.....	9.9 times	3.9 times

<sup>1</sup> See James, Talks to Teachers, 101.

TABLE XV

RECORDS OF TEN PERSONS, GIVING IN THE FIRST COLUMN THE AVERAGE DURATION OF THE "IN" PERIODS WHEN AN EFFORT WAS MADE TO HOLD THE FIGURE AS "IN," AND IN THE SECOND COLUMN THE NORMAL DURATION OF THE "IN" PERIODS TAKEN FROM TABLE XIII

1.....	17. "	4.4"
2.....	18. "	5.1"
3.....	16.7"	8.2"
4.....	9. "	3.0"
5.....	8.5"	3.2"
6.....	21.2"	6.9"
7.....	4.2"	2.0"
8.....	20. "	5.0"
9.....	5.9"	3.2"
10.....	4.6"	4. "
Average.....	12.5"	4.5"

attempt to hold the figure in the "in" position. If it shifts into the "out" position try to get it back as soon as possible into the "in" position. Find the average duration of the "in" periods. How do they compare with the normal length of the "in" periods as found in experiment 2 a?

Discuss the following questions:

1. Give an illustration from school work of securing attention through the law of intensity, through the law of contrast, through the law of clearness, through the law of counter attraction.
2. Which laws are most suitable as permanent means of securing attention?

3. What practical applications has the principle involved in experiment b (1) and (2)?

For further practical exercises see Thorndike, *Principles of Teaching*, 107-109; O'Shea, *Dynamic Factors in Education*, 24-25.

## CHAPTER XII

### MEMORY

**THE** practical problem in the field of memory is, How may we memorize or learn in the most economic manner? A considerable number of principles of economy in learning have been established by extensive investigations. The experiments that follow will deal with only a few of these principles.

**1. Learning in Parts or as a Whole.** Is it more economical to memorize a given amount of material piecemeal, or as an entirety? For this test the following two selections of poetry from Lorenzo's *Laudi Spirituali* are to be used.

Memorize selection A part by part, making such divisions as seem convenient. Consider it memorized as soon as you are able to repeat it correctly without looking at the book. Record the number of minutes required. In both of the following selections work as intensively as you can and try to disregard any prejudice that you may have as to what the best method of memorizing is.

## SELECTION A

O let this wretched life within me die  
 That I may live in thee, my life indeed;  
 In thee alone, where dwells eternity,  
 While hungry multitudes death's hunger feed.  
 I list within, and hark! Death's stealthy tread!  
 I look to thee, and nothing then is dead.  
 Then eyes may see a light invisible  
 And ears may hear a voice without a sound.

After a few minutes' rest, memorize selection B by reading the entire selection through from beginning to end each time. Continue this until you are able to repeat it without consulting the text. Work with maximum concentration, as in the first selection.

## SELECTION B

When, sweet and beauteous Master, on that day,  
 Reviewing all my loves with aching heart,  
 I take from each its bitter self away,  
 The remnant shall be thou, their better part.  
 This perfect sweetness be his single store  
 Who seeks the good; this faileth nevermore.  
 A thirst unquenchable is not beguiled  
 By draught on draught of any running river.

How do the two methods compare? The greater economy of the "whole" method does not always appear in shorter amount of time required for it, but often in the greater permanence which is indicated by the shorter

time necessary to relearn material acquired by the "whole" method. To demonstrate this point, find the time necessary to relearn the two selections either twenty-four or forty-eight hours later.

TABLE XVI

RECORDS OF SIX PERSONS

	Part method	Whole method
1.....	3'	2' 15"
2.....	3'	2' 45"
3.....	5'	7'
4.....	5'	3' 42"
5.....	7' 50"	7' 30"
6.....	5'	3'
Average.....	4' 48"	4' 22"

**2. The Effect of Incorrect Repetition.** The problem of the next experiment is to determine the retarding effect of incorrect repetitions upon the speed of learning.

Obtain a deck of ordinary playing cards. Remove from it all the aces, kings, queens, jacks, and tens, leaving altogether thirty-two cards. Take eight pieces of paper and number them from two to nine. Place these on the table before you about six inches apart, in irregular order, in the form of a semicircle. Shuffle the cards well. Take them into your left hand with their backs turned toward you. Then distribute them as rapidly as you can into eight piles indicated by the slips of paper. That is, put all the fours on one pile beside the slip bearing that number, and all the fives on one pile, etc. Try to avoid all mistakes. If you discover having made a mistake, do



not stop to correct it, as you would lose too much time on account of it. Record the exact time required to make the distribution. In this manner make ten distributions. Then have your partner rearrange the eight slips of paper in a different order. Before doing this, write down the order in which the slips are placed. Make two distribu-

TABLE XVII

## RECORDS OF THIRTEEN PERSONS

	I	2	3	4	5	6	7	8	9	10	11	12	13
1.....	54	55	60	82	49	55	69	52	69	60	70	65	60
2.....	49	45	58	68	42	55	69	44	54	54	60	60	58
3.....	43	40	50	69	40	50	63	43	54	51	54	52	50
4.....	43	40	55	60	38	48	55	40	57	48	56	50	55
5.....	41	38	50	50	37	48	50	40	52	44	47	50	50
6.....	43	41	54	55	33	42	43	38	49	40	57	44	54
7.....	40	38	59	52	36	42	40	37	54	43	56	47	55
8.....	38	39	50	47	30	38	40	36	48	45	50	45	59
9.....	39	35	49	45	33	37	42	36	56	43	50	44	50
10.....	36	37	..	45	32	35	40	37	50	39	50	44	49
Rearranged order													
11.....	60	52	55	69	45	45	69	40	54	53	56	55	55
12.....	44	45	55	60	40	45	55	37	52	54	57	55	55
Original order													
13.....	48	43	49	50	40	38	54	42	46	54	50	50	49
14.....	45	35	..	46	34	37	40	38	..	45	46	48	..
15.....	40	..	..	47	38	37	..	36	..	44	..	47	..
16.....	44	..	..	48	32	35	..	..	..	38	..	42	..
17.....	39	..	..	45	..	..	..	..	..	..	..	..	..
18.....	38	..	..	..	..	..	..	..	..	..	..	..	..
19.....	38	..	..	..	..	..	..	..	..	..	..	..	..
20.....	37	..	..	..	..	..	..	..	..	..	..	..	..

tions according to this new arrangement. Then place the slips in the same order as they were originally and make

several distributions until you shall reach the speed you had attained before the two incorrect distributions. Be sure that the cards are thoroughly shuffled before each distribution.

Make a table of your results similar to the sample records given in Table XVII.

**3. Pauses in Memorizing.** The object of the following test is to determine the effect of a short pause after learning. Use the following lists of words. Your partner will read to you each list once, reading at the rate of one word per second. Immediately after the first list has been read turn to some earlier part of the book and engage in rapid reading for thirty seconds. When the thirty seconds are over, which will be indicated by your partner, write down as many words of the list read to you as you remember.

After about two minutes, list two will be read to you. But during the thirty seconds following that, you are not to work, but to allow your mind to rest or wander as it will. However, do not repeat the words that were

1. Poor, bind, draw, look, hang, sort, vein, plan.
2. Evil, mark, wait, face, than, view, work, come.
3. Call, grow, cast, term, down, suit, cold, leaf.
4. Care, bold, trim, take, bite, stop, wake, pain.
5. Blow, busy, coat, pull, pour, stay, jerk, have.
6. Pick, this, rise, snap, give, from, more, that.
7. Tilt, step, zeal, fall, thou, damp, iron, find.
8. Lead, blue, turn, once, pray, rude, just, yard.

read to you. Then write down all the words you remember.

In like manner use the remaining lists of words. The odd-numbered lists are to be followed in each case by rapid reading for thirty seconds, and the even-numbered lists by rest periods of thirty seconds.

The following lists are to be used upon your partner:

1. Here, want, your, beat, room, gold, time, rock.
2. Rear, moat, walk, hand, tell, heir, pass, mind.
3. Fire, like, part, form, will, fear, clad, reef.
4. Make, firm, live, yarn, wing, fold, good, hard.
5. Home, fare, roll, mean, gone, gray, shot, hope.
6. What, seem, hate, crow, lime, chin, cure, lend.
7. Knot, free, some, each, slow, coal, sick, boat.
8. Long, comb, song, less, calf, when, wood, dust.

TABLE XVIII

RECORDS OF TEN PERSONS, SHOWING THE AVERAGE NUMBER OF WORDS  
REMEMBERED PER GROUP

	Pause Occupied	Pause Unoccupied
1.....	4.7	5.7
2.....	4.8	6.0
3.....	5.2	5.8
4.....	3.8	4.2
5.....	3.0	5.0
6.....	3.0	4.3
7.....	3.5	6.0
8.....	4.0	5.2
9.....	3.2	5.7
10.....	2.3	5.3
Average.....	3.5	5.3

Find the average number of words remembered from the odd-numbered and the average number remembered from the even-numbered lists.

4. **Comprehension and System.** The purpose of the next two tests is to demonstrate two maxims of memory. (a) Understand what you wish to remember, and (b) systematize what you wish to remember.

a. *Sense versus Nonsense Material.* Things understood clearly are remembered more readily. To show this experimentally, compare the length of time required to learn ten monosyllabic nouns with the time required to learn ten nonsense syllables. A list of syllables was assigned for memorizing in Chapter VIII, and the results of this test may be used for comparison, so that no new list needs to be learned.

Find the time required to learn the following list of ten words:

spade  
moon  
fox  
corn  
road  
town  
mink  
light  
sand  
knife

Compare the time of this with the time needed for the first list of syllables in Chapter VIII. The sense material

at once arouses so many more connections that it is remembered much more readily.

TABLE XIX

## RECORDS OF ELEVEN PERSONS

	Syllables	Words
1.....	1' 8"	40"
2.....	1'	50"
3.....	2' 30"	42"
4.....	1' 40"	1' 5"
5.....	1'	45"
6.....	1' 20"	55"
7.....	3'	2'
8.....	1' 30"	1'
9.....	3'	1' 45"
10.....	2' 30"	2'
11.....	1' 20"	30"
Average.....	1' 49"	1' 1"

b. Find the time required to commit to memory the following list of items. Consider them learned as soon as you are able to repeat, in the order in which they are printed, all the items, and their equivalents or dates, without consulting the text. Learn by the "whole" method, that is, read the entire list each time. Work as intensively as you can.

## LIST A

Battle of Poitiers	1356 A. D.
Katheko =	come down
Karphe =	hay
$782+465 =$	1247
Invention of grain-binder	1854 A. D.
$624+832 =$	1456
Arch of Constantine built	314 A. D.
Zulon =	timber
$901+477 =$	1378
Battle of Colline Gate	82 B. C.
$758+546 =$	1304
Invention of typewriter	1855 A. D.
Harkos =	oath
$683+459 =$	1142
Ochthe =	bluff

After a few minutes of rest learn the following list of items. Proceed also by the "whole" method. Record the time. Work intensively.

## LIST B

## Five historical dates:

Destruction of Corinth	146 B. C.
Battle of Strassburg	357 A. D.
Battle of Agincourt	1415 A. D.
Invention of cream separator	1879 A. D.
Invention of gasoline engine	1875 A. D.

## Five Greek words:

Chalepos =	difficult
Chrema =	wealth
Phluaros =	nonsense
Poleo =	to sell
Skeneo =	to encamp

## Five additions:

$593 + 854 =$	1447
$697 + 561 =$	1258
$729 + 637 =$	1366
$823 + 576 =$	1399
$945 + 363 =$	1308

Both lists contain the same number of items of each class. In List A they are arranged in chance order, while in List B they are systematized and grouped according to their classes.

Compare the time of learning the two lists. What inference do you draw?

TABLE XX  
RECORDS OF TEN PERSONS

	List A	List B
1.....	12'	5'
2.....	10'	5'
3.....	19'	14'
4.....	9'	7'
5.....	15'	12'
6.....	15'	9' 40"
7.....	11' 30"	6'
8.....	14'	11'
9.....	20'	14'
10.....	15'	8' 10"
Average.....	14' 3"	9' 11"

Discuss the following questions:

1. Give several concrete applications of the principle that the "whole" method is better than the "part" method in learning.

2. Give several instances in which the detrimental effect of incorrect repetitions would be shown.

3. Give one illustration in the study of history and one in the study of geography of the principle involved in experiment b.

For additional exercises consult Thorndike, *Principles of Teaching*, 123-127.



## CHAPTER XIII

### WORK AND FATIGUE

THE object of the experiment in this chapter is to demonstrate some means of measuring continuous work, and to show the changes and, particularly, the effects of fatigue in continuous work.

1. **Mental Work and Fatigue.** In order to measure mental fatigue, it is necessary to employ a form of test which involves the lowest minimum of muscular and sensory work. Many such tests have the objection of involving considerable muscular activity. For example, the cancellation test is largely a test of fatigue of eye muscles. The tapping tests likewise are tests mostly of muscular fatigue.

The type of work which has proved most successful is some form of arithmetical calculation. In the present experiment the work will consist of mental addition.

Be comfortably seated in a quiet room. Your partner will announce to you a number consisting of two digits. Add six to this number, then add seven to this new sum, and then eight to that, then nine, and then again six,

seven, eight, and nine in rotation, etc. When the sum has reached one hundred or more drop the extreme left hand digit and continue with the two remaining digits. For example, if the number given you were 80, then your consecutive sums would be 80, 86, 93, 101, 10, 16, 23, 31, etc. Your partner will announce a new number every thirty seconds. In each case add six, seven, eight, and nine in rotation to the sum you get after each addition. In order to understand thoroughly the conditions of the experiment, use for preliminary trials the following two numbers which will not occur among the numbers of the regular experiment, 40, and 60.

Close your eyes and add just as rapidly as you can. Your partner will give you a new number every thirty seconds. Speak your sums aloud so that your partner can hear them and follow the columns below, which give the correct succession of answers. If you make a mistake he will write your number opposite the correct one. At the end of every thirty seconds he will make a check mark to indicate how many numbers you had added and at the same time give you a new number which will be the one at the top of the next column. Lose no time when a new number is announced, but start at once with it and add at your maximum speed until another number is given you, and so on.

## 174 EXPERIMENTS IN EDUCATIONAL PSYCHOLOGY

40	60
46	66
53	73
61	81
70	90
76	96
83	103
91	11
100	20
6	26
13	33
21	41
30	50
36	56
43	63
51	71
60	80
66	86
73	93
81	101

Now begin with the regular experiment. The numbers to be announced every thirty seconds are the ones at the top of the columns. It is absolutely necessary that you should work just *as hard and as fast as you can*. The entire test will take thirty minutes, as there are sixty columns.<sup>1</sup>

The class should be divided into two groups. One should work continuously for thirty minutes, while the other should take a rest of two minutes after the first fifteen minutes of work.

<sup>1</sup> The numbers that are used for "starters" comprise all the numbers between 0 and 100 which will not produce sums whose right hand digit is 0. All these were omitted because the additions in such cases are decidedly easier.

The columns are long enough so that no one is apt to go beyond any one in the allotted thirty seconds. If this should occur your partner should make a check mark for every number beyond the column.

28	52	33	58	26	81	46	72	68	53
34	58	39	64	32	87	52	78	74	59
41	65	46	71	39	94	59	85	81	66
49	73	54	79	47	2	67	93	89	74
58	82	63	88	56	11	76	2	98	83
64	88	69	94	62	17	82	8	4	89
71	95	76	1	69	24	89	15	11	96
79	3	84	9	77	32	97	23	19	4
88	12	93	18	86	41	6	32	28	13
94	18	99	24	92	47	12	38	34	19
1	25	6	31	99	54	19	45	41	26
9	33	14	39	7	62	27	53	49	34
18	42	23	48	16	71	36	62	58	43
24	48	29	54	22	77	42	68	64	49
31	55	36	61	29	84	49	75	71	56
39	63	44	69	37	92	57	83	79	64
48	72	53	78	46	1	66	92	88	73
54	78	59	84	52	7	72	98	94	79
61	85	66	91	59	14	79	5	1	86
69	93	74	99	67	22	87	13	9	94

# 176 EXPERIMENTS IN EDUCATIONAL PSYCHOLOGY

35	11	36	62	98	43	85	51	66	22
41	17	42	68	4	49	91	57	72	28
48	24	49	75	11	56	98	64	79	35
56	32	57	83	19	64	6	72	87	43
65	41	66	92	28	73	15	81	96	52
71	47	72	98	34	79	21	87	2	58
78	54	79	5	41	86	28	94	9	65
86	62	87	13	49	94	36	2	17	73
95	71	96	22	58	3	45	11	26	82
1	77	2	28	64	9	51	17	32	88
8	84	9	35	71	16	58	24	39	95
16	92	17	43	79	24	66	32	47	3
25	1	26	52	88	33	75	41	56	12
31	7	32	58	94	39	81	47	62	18
38	14	39	65	1	46	88	54	69	25
46	22	47	73	9	54	96	62	77	33
55	31	56	82	18	63	5	71	86	42
61	37	62	88	24	69	11	77	92	48
68	44	69	95	31	76	18	84	99	55
76	52	77	3	39	84	26	92	7	63

38	73	25	41	76	12	78	13	95	31
44	79	31	47	82	18	84	19	1	37
51	86	38	54	89	25	91	26	8	44
59	94	46	62	97	33	99	34	16	52
68	3	55	71	6	42	8	43	25	61
74	9	61	77	12	48	14	49	31	67
81	16	68	84	19	55	21	56	38	74
89	24	76	92	27	63	29	64	46	82
98	33	85	1	36	72	38	73	55	91
4	39	91	7	42	78	44	79	61	97
11	46	98	14	49	85	51	86	68	4
19	54	6	22	57	93	59	94	76	12
28	63	15	31	66	2	68	3	85	21
34	69	21	37	72	8	74	9	91	27
41	76	28	44	79	15	81	16	98	34
49	84	36	52	87	23	89	24	6	42
58	93	45	61	96	32	98	33	15	51
64	99	51	67	2	38	4	39	21	57
71	6	58	74	9	45	11	46	28	64
79	14	66	82	17	53	19	54	36	72

# 178 EXPERIMENTS IN EDUCATIONAL PSYCHOLOGY

86	92	18	63	45	91	16	82	88	23
92	98	24	69	51	97	22	88	94	29
99	5	31	76	58	4	29	95	1	36
7	13	39	84	66	12	37	3	9	44
16	22	48	93	75	21	46	12	18	53
22	28	54	99	81	27	52	18	24	59
29	35	61	6	88	34	59	25	31	66
37	43	69	14	96	42	67	33	39	74
46	52	78	23	5	51	76	42	48	83
52	58	84	29	11	57	82	48	54	89
59	65	91	36	18	64	89	55	61	96
67	73	99	44	26	72	97	63	69	4
76	82	8	53	35	81	6	72	78	13
82	88	14	59	41	87	12	78	84	19
89	95	21	66	48	94	19	85	91	26
97	3	29	74	56	2	27	93	99	34
6	12	38	83	65	11	36	2	8	43
12	18	44	89	71	17	42	8	14	49
19	25	51	96	78	24	49	15	21	56
27	33	59	4	86	32	57	23	29	64

75	21	96	42	48	83	55	61	56	32
81	27	2	48	54	89	61	67	62	38
88	34	9	55	61	96	68	74	69	45
96	42	17	63	69	4	76	82	77	53
5	51	26	72	78	13	85	91	86	62
11	57	32	78	84	19	91	97	92	68
18	64	39	85	91	26	38	4	99	75
26	72	47	93	99	34	6	12	7	83
35	81	56	2	8	43	15	21	16	92
41	87	62	8	14	49	21	27	22	98
48	94	69	15	21	56	28	34	29	5
56	2	77	23	29	64	36	42	37	13
65	11	86	32	38	73	45	51	46	22
71	17	92	38	44	79	51	57	52	28
78	24	99	45	51	86	58	64	59	35
86	32	7	53	59	94	66	72	67	43
95	41	16	62	68	3	75	81	76	52
1	47	22	68	74	9	81	87	82	58
8	54	29	75	81	16	88	94	89	65
16	62	37	83	89	24	96	2	97	73



93	65	71	15	28	52	33	58	26	81
99	71	77	21	34	58	39	64	32	87
6	78	84	28	41	65	46	71	39	94
14	86	92	36	49	73	54	79	47	2
23	95	1	45	58	82	63	88	56	11
29	1	7	51	64	88	69	94	62	17
36	8	14	58	71	95	76	1	69	24
44	16	22	66	79	3	84	9	77	32
53	25	31	75	88	12	93	18	86	41
59	31	37	81	94	18	99	24	92	47
66	38	44	88	1	25	6	31	99	54
74	46	52	96	9	33	14	39	7	62
83	55	61	5	18	42	23	48	16	71
89	61	67	11	24	48	29	54	22	77
96	68	74	18	31	55	36	61	29	84
4	76	82	26	39	63	44	69	37	92
13	85	91	35	48	72	53	78	46	1
19	91	97	41	54	78	59	84	52	7
26	98	4	48	61	85	66	91	59	14
34	6	12	56	69	93	74	99	67	24

Construct a curve, similar to the one in Fig. 25, to show the number of additions made in every five thirty-second period. Also indicate whether you belong to the group with or without the two minutes' rest.

It is perhaps impossible to select an activity in which there is no increase in efficiency due to practice. The type of work used here involves a relatively small amount of practice. It is obvious that the two factors of practice and fatigue which appear in all continuous work tend to counteract each other. The former tends to make the curve rise while the latter tends to make it drop. The two factors may, however, be separated. If we allow a period of rest of two minutes at the end of every five minutes of work we reduce the effects of fatigue and get the natural rise of the curve due to practice. The upper one in Fig. 25 is the composite curve of seven persons obtained in this manner. The lower one is the composite of ten persons working continuously. The former may be called the practice curve and the latter the fatigue curve. The

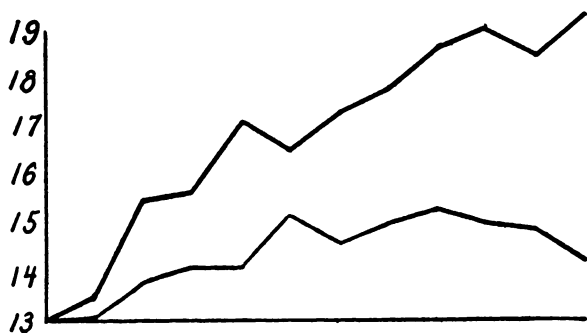


FIG. 25.

average gain of the seven records in the practice curve, comparing the last five half-minute periods with the first five, is 57 per cent., while the average gain of the ten records in the fatigue curve is 10 per cent.

**2. Muscular Work and Fatigue.** Perhaps the best apparatus for measuring muscular work and fatigue is the Mosso ergograph, which is to be used in this experiment.<sup>1</sup>

Fasten the fingers, hand, and forearm of the right arm firmly in the arm rest, leaving only the middle finger free. Attach the finger cap to the middle finger so that the wire is taut when the finger is in resting position. With this finger lift the weight regularly every two seconds. Follow a metronome which has been set to beat sixty times per minute. On the first stroke raise the weight as high as you can and on the second lower it to the resting position, then on the next stroke lift it again, etc. Make a maximum pull each time and continue until the finger is completely exhausted. After a rest of thirty seconds make another record in the same manner. To show the effect of different intervals of rest, half of the class should rest thirty seconds and the other half one minute between the two records.

Dip the record paper in shellac and hang it up to dry. After it is thoroughly dry mount it upon stiff paper and preserve it among your notes. Compare the number and

<sup>1</sup> This experiment will require careful supervision by the instructor in charge to see that the apparatus is properly set up.

The ergograph may be obtained from C. H. Stoelting Co., 121 N. Green St., Chicago, Ill.

height of the pulls made in the two records. Also notice whether there are any rhythmic variations in the decrease of strength.

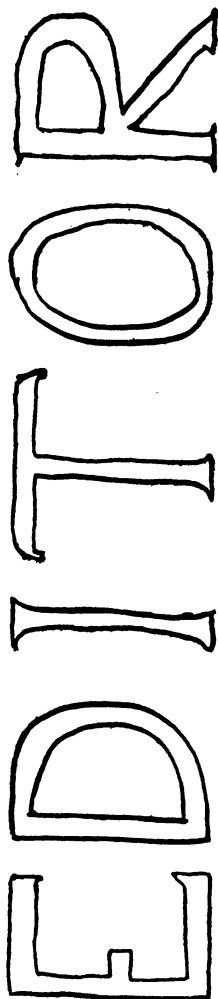


FIG. 26.



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